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TESTABILITY/DIAGNOSTICS ENCYCLOPEDIA PROGRAM (Phase 1) Testability/Diagnostics Linkages in Mil-Standards and Handbooks

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The military services have been experiencing problems in the adequacy of their weapon systems' diagnostic capabilities. Military standards and handbooks are an important factor in acquiring these diagnostic capabilities. The structure and content of existing standards and handbooks is not adequately supporting this process.

This report contains specific modifications to 24 existing military standards and handbooks required to assure the acquisition of an adequate weapon system diagnostic capability. Of the proposed revisions to these 24 documents, three are critical to improving this acquisition process. They are:

(a) MIL-STD-2165, Testability Program for Electronic Systems and Equipments, recommended to address the programmatic requirements for a weapon system's entire diagnostic capability;

(b) MIL-STD-415, Design Criteria for Test Provisions for Electronic Systems and Associated Equipment, recommended to cover design criteria for a weapon system's entire diagnostic (over)

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Item 19. Abstract (Cont'd)

capability; and

(c) MIL-STD-1521, Technical Reviews and Audits for Systems, Equipment, and Computer Programs, recommended to emphasize, audit and review procedures for a weapon system's entire diagnostic capability.

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PREFACE

The military services have been experiencing problems in the adequacy of their weapon systems' diagnostic capabilities. Military standards and handbooks are an important factor in acquiring these diagnostic capabilities. The structure and content of existing standards and handbooks are not adequately supporting this process. The report identifies the necessary modifications to existing military standards and handbooks which are required to correct these deficiencies.

I. INTRODUCTION.

The primary objective of the Testability/Diagnostic Encyclopedia Program is to develop the required products, capabilities, data, and guidance for the cost-effective and coordinated specification and treatment of equipment and system testability/diagnostics through every phase of the Acquisition Cycle. The first portion (Part I) of this program, covered by contract (F30602-86-C-0096), is aimed at ascertaining the adequacy of existing military standards and handbooks in dealing with the application of required testability and diagnostic principles and techniques utilized in the acquisition of weapon systems and providing specific improvements in these standards and guides, as required. The specific objectives of this effort (Part I) are to:

(a) Review existing military standards and handbooks in the fields of engineering, reliability, maintainability, logistics, and associated hardware, software, documentation, and training with respect to essential testability/diagnostic coverage and provide draft revisions or modifications, as necessary, to provide that coverage/consideration; and,

(b) Identify those diagnostic/testability areas which require the development of additional military standards and handbooks and provide rough drafts of their content.

As depicted in Figure 1-1, the technical approach for achieving these objectives is divided into three phases. Phase I deals with the identification of existing and planned standards and handbooks and the determination of requirements for standards and handbooks. Phase II deals with the comparison of the requirements for standards and handbooks with the contents of existing and planned standards and handbooks. The output of this phase is the identification and scoping of changes to existing standards and handbooks and the identification of the need for new standards and handbooks, along with a recommended documentation structure. Phase III deals with the end products of this contract, which include either outlines or drafts of proposed changes for existing documents and outlines and summaries for proposed new documents.

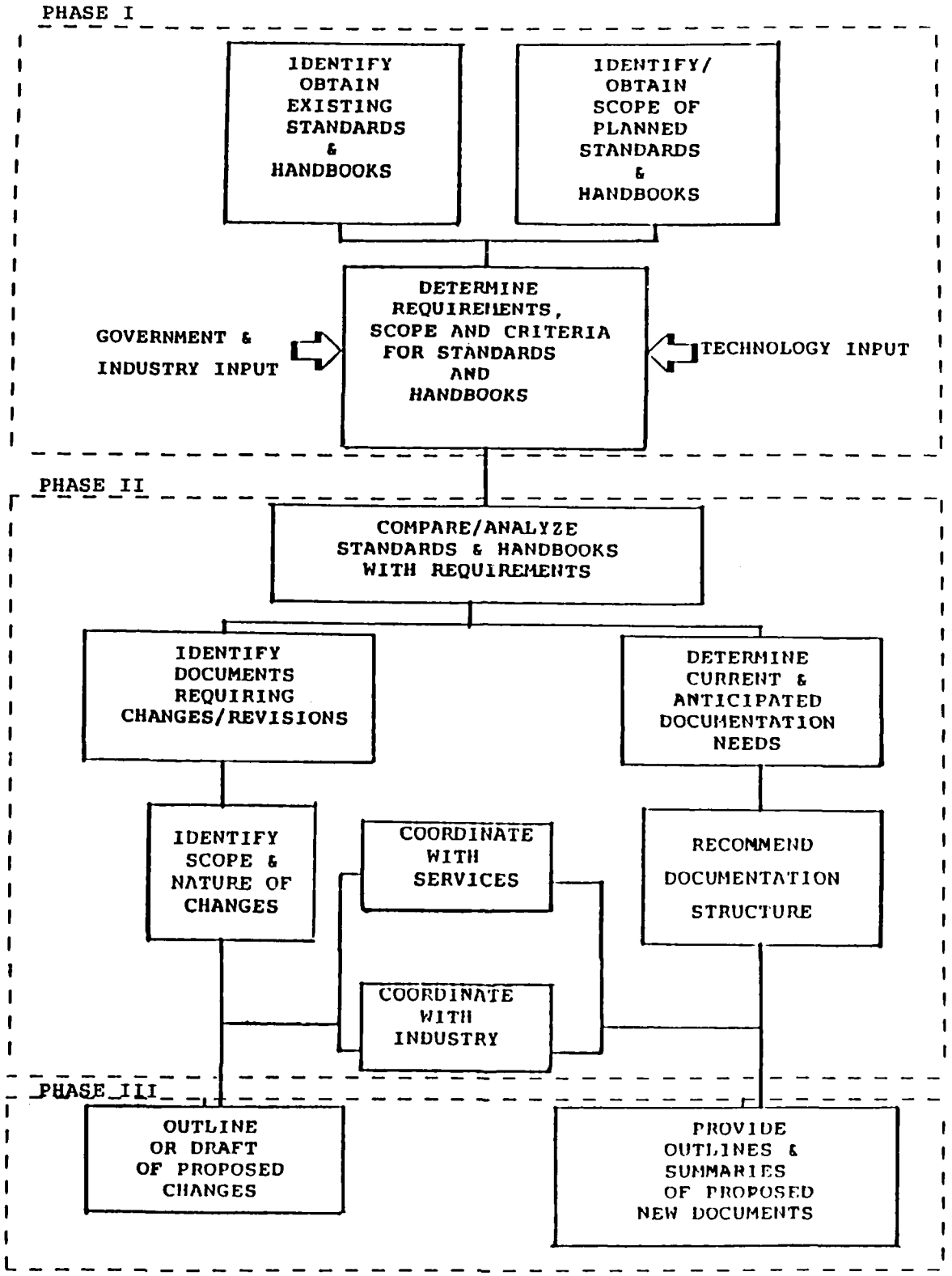

Figure 1-1. Technical Approach

This Final Technical Report for Part I of the Testability/Diagnostics Encyclopedia Program documents the results of the above effort.

Section II of this report defines some important terms used in the report. Section III describes the technical approach, and Section IV delineates the conclusions and recommendations, including the Document Improvement Reports, emanating from this analysis effort. Section V is a summary.

II. DEFINITIONS.

To fully understand the contents of this report, it is necessary to understand the definitions of four terms used throughout this report. The first term is "testability," which is defined as "a design characteristic which allows the status of the unit to be confidently determined in a timely fashion." Therefore, testability may be regarded as inherent to the unit's design.

"Diagnostics" is defined as "the act of performing and the techniques used in determining and isolating the cause of malfunctions."

"Integrated Diagnostics" is defined as "a structured process which maximizes the effectiveness of diagnostics by integrating pertinent elements, such as testability, automatic and manual testing, training, maintenance aiding, and technical information, as a means for providing a cost-effective capability to detect and unambiguously isolate all faults known or expected to occur in weapon systems and equipment in order to satisfy weapon system mission requirements."

"Diagnostic capability" refers to all the capabilities associated with the detection and isolation of faults, including automatic and manual testing, training, maintenance aiding, and technical information.

It is important to understand that Integrated Diagnostics is a structured design process for acquiring a diagnostic capability.

III. TECHNICAL APPROACH.

A. Identification of Documents to be Considered.

The Statement of Work for this program identified a number of standards and handbooks in the fields of reliability, maintainability, system engineering, logistics, and testing which, as a minimum, were to be examined. As part of Phase I of this contract, the DoD Index of Specifications and Standards was thoroughly reviewed and a number of additional documents were added to the scope of the project.

In addition to this, 14 Standardization Areas were identified. A number of Standardization Plans, either existing or under preparation, were available. Information contained in these plans would assist in determining future standardization activities related to revising existing documents and plans for developing new documents. As a result, the scope of a number of documents to be developed in the near future were included in this project. Of the 14 Standardization Areas identified, only Human Factors, Maintainability, and Reliability had standardization plans which were both pertinent and up-to-date.

Appendix A is a listing of existing and planned documents which were incorporated in this analysis. Although the contract's Statement of Work (SOW) identified a minimum core of 14 standards and two handbooks, the number of documents, which conceivably could have had testability and diagnostic implications, was much higher. As summarized in Figure 3-1, 54 standards and 28 handbooks and guides were included. Twenty percent of the standards reviewed require major modifications to adequately deal with testability and diagnostics. Another 18% require minor revisions. Only a small percentage of handbooks and guides require revision.

NUMBER OF DOCUMENTS	MILITARY STANDARDS	MILITARY HANDBOOKS
REVIEWED	54	28
MAJOR REVISION REQUIRED	11	3
MINOR REVISION REQUIRED	10	0
NO REVISION REQUIRED	33	25

Figure 3-1. Numerical Summary of Analysis Results

B. Establishing Requirements for Standards and Handbooks.

As part of Phase I activity, the requirements for standards and handbooks were established. This analysis was approached without referring to existing documents. Rather, the diagnostic activities relating to the weapon system life cycle were analyzed in relation to standards and handbook requirements. The top-down approach used for determining these documentation requirements is described in Appendix B of this report. The analysis performed during Phase I resulted in establishing the eight basic documentation requirements described below.

Requirement #1 -- Establishing Diagnostic Requirements and Allocating These Requirements for System, subsystem, and Unit Levels.

A need exists for establishing diagnostic requirements and allocating these requirements at system, subsystem, and unit levels. This includes:

- Translating weapon system mission and performance requirements to diagnostic requirements
- Means for trading-off various diagnostic elements to achieve optimization
- Allocating diagnostic requirements to these diagnostic elements
- Means for specifying diagnostic requirements in contractual documents.

Requirement #2 -- Describing Various Testability/ Diagnostic Tasks Which Must Be Undertaken During Each Phase of Weapon System Acquisition.

A requirement exists for programmatic-type documents which describe the various tasks which must be undertaken during each phase of weapon system acquisition. This requirement includes a means for integrating the diagnostic requirements that are of concern to the system engineering, logistic support, reliability, and maintainability of weapon systems. The requirement addresses both planning and program implementation.

Requirement #3 -- Designing the Diagnostic Capability.

A requirement exists to assure proper design of the weapon system's diagnostic capability. This includes:

- Integrating the entire diagnostic design process, beginning with the establishment of diagnostic requirements and extending through the maturation of the diagnostic capability

- Assuring that design criteria exists for both the hardware and the software which constitute the diagnostic capability.

Requirement #4 -- Conducting Design Reviews.

A requirement exists to conduct a number of technical reviews and audits during weapon system acquisition to assure that an adequate diagnostic capability is attained.

Requirement # 5 -- Analyzing and Assessing the Performance of the Diagnostic Capability (During Prime System/Weapon System Design).

A requirement exists to analyze and assess the performance of the diagnostic capability throughout the design of the weapon system.

Requirement #6 -- Assuring the Delivery of an Adequate Diagnostic Capability.

A requirement exists to assure the delivery of an adequate diagnostic capability by performing and conducting demonstration and maturation programs and procedures. The requirement for unambiguous fault detection and isolation to the lowest replaceable unit at each maintenance level requires a comprehensive re-look at these evaluation procedures and techniques.

Requirement #7 -- Collecting and Analyzing Data on the Performance of the Diagnostic Capability.

A requirement exists for establishing procedures for collecting and analyzing data on performance of the diagnostic capability. This requirement begins in the early stages of weapon system development and continues throughout the life of the weapon system. This process must include the requirement for the compatibility between the contractor's data collection system and the military service collection system.

Requirement #8 -- Standardization Definitions.

A requirement exists to standardize on the definitions utilized in acquiring and fielding a weapon system diagnostic capability. These terms must be standardized in order to assure unambiguous understanding of diagnostic requirements and their use throughout the life of the weapon system.

Figure 3-2 depicts the relationship of the first seven requirements to the weapon system life cycle (WSLC).

C. Identifying/Scoping of Modifications to Existing Documents and Need for New Documents.

The objectives of Phase II were twofold. The first was to determine the effectiveness of the individual, existing documents so that needed revisions to these documents could be identified. The second was to determine how well these documents played together so that gaps in required documentation could be

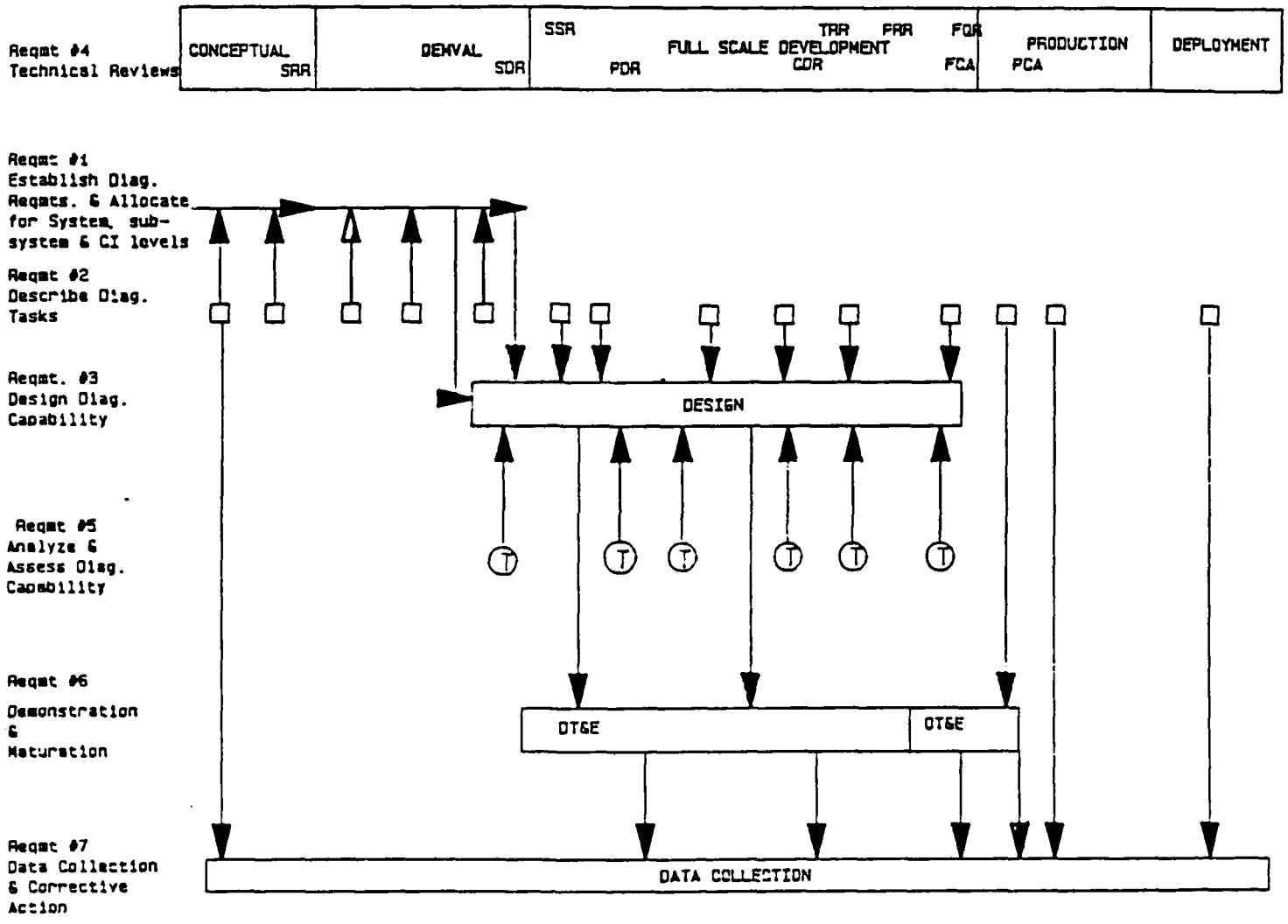

Figure 3-2. Relationship of Documentation Requirements to the Weapon System Life Cycle

identified. These gaps could be filled by revising an ex-existing document or by creating a new one. This latter objective deals with the integration of documents and the traceability among documents. Appendix B describes this analysis and its results.

D. Coordination of Phase II Effort (Identification and Scoping of Documents).

Before embarking on Phase III of this program, which addressed detailed modifications and outlines of documents, considerable time was spent in coordinating the initial analysis of proposed actions with government and industry personnel. Copies of the Phase II report were sent to the DoD preparing activities for each document, subsequent to discussions with these responsible parties. In addition, coordination with industry and other DoD personnel was achieved through two meetings with the National Security Industrial Association's (NSIA) Integrated Diagnostic Group. The results of these two meetings are contained in their report--a copy of which is included as Appendix C. Their conclusions and recommendations were thoroughly reviewed and considered during the Phase III effort.

IV. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS.

The output of Phase III activity was specific on proposed revisions to 24 standards and handbooks. Document Improvement Reports, which are located at the end of this section of the report, were prepared for each of these 24 documents. Fourteen of these documents require major revisions and, of these fourteen, only three are considered to be critical (i. e., MIL-STDs 2165, 415, and 1521). With the exception of guidance which is required to implement the integrated diagnostic process, no new documents are proposed.

In completing the final phase of this effort, a number of key findings and conclusions were evident, which threaded their way through many of these documents. These are summarized below.

A. Findings and Conclusions.

- o Specification of the Diagnostic Capability.

  A means for specifying diagnostic requirements in RFPs, Statements of Work, and System Specifications presents a formidable problem. The National Security Industrial Association's "Guidelines for Preparation of Diagnostic Requirements" addresses the problem facing both the government and the contractor program manager and is a first step in solving this problem. For the System Specification, which is normally written by the contractor, there are almost as many methods for specifying diagnostics as there are contractors. Virtually none of the available specification methods address all the diagnostic elements. Quantitatively addressing technical information and technical orders, quantitatively addressing training and personnel requirements, and quantitatively addressing performance monitoring requirements are examples of this problem. Specification must be made at prime system level and as the design progresses, quantitative allocations must be made to each of the diagnostic elements. In addition, provisions for prognostics, quality assurance, etc., must be addressed. The allocation of each of the diagnostic elements in relation to 100% fault detection and fault isolation requirements at each maintenance level presents an additional problem, for it is usually a combination of diagnostic elements which satisfy a specific diag-

nostic requirement. For example, if built-in test, plus a technical order, are utilized to fault isolate to a given unit, what percentage is allocated to each? Standard methods for specifying diagnostic requirements need to be developed and documented. Without a sound methodology, the design of the entire diagnostic capability is compromised.

- Integrating the "Ilities."

  Providing an effective diagnostic capability is based on sound system engineering principles and methods. Thus the acquisition of a suitable diagnostic capability is based on the system engineering process defined in MIL-STD-499A. Emanating from this standard are the logistic, reliability, maintainability, testability, human engineering, and training programmatic standards, which define tasks which must be undertaken in relation to the weapon system acquisition phases. Although each of these standards relate to one another and this relationship is addressed in each standard, the traceability throughout the system engineering process for developing the diagnostic capability is not readily apparent. Duplication exists among these standards. For instance, the required planning documents and the demonstration programs inherently lead to duplication. This duplication not only creates unnecessary paper but, if not controlled, can manifest itself in overlapping engineering activities. A revolutionary change would be to incorporate the "ilities" into one system engineering document. However, at present there are some promising near-term solutions. One solution is the integration of the deliverables required by the consolidation of Data Item Descriptions.

- Providing a Cohesive Diagnostic Design Process.

  The diagnostic design process is controlled by a number of military standards, handbooks, and guides. Among these are standards which apply to failure modes and effects analysis, on-line test, test requirement documents, test program sets, and technical orders. It is essential that the diagnostic design process integrate and utilize the products developed under reliability, maintainability, logistic support analysis, and tes-

tability. Generation of on-line diagnostics (e. g., BIT, test point placement, in-flight monitoring, maintenance-aiding) is particularly fractionated. Methods and tools for testability and fault-tolerant design are required. Vertical testability among the various maintenance levels is oftentimes neglected. Thus the main objective is to assure that a methodology which promotes a cohesive diagnostic design process is reflected in the standards, DIDs, handbooks, and guides.

The severity of this problem cannot be overemphasized. The standards which control the diagnostic design process are, for the most part, adequate for their specific purpose. When taken collectively, the process is so fractionated that effective implementation is virtually impossible. As an example, repeated below is paragraph 4.7 of MIL-STD-756B.

"4.7 Coordination of Effort. Reliability and other organizational elements shall make coincident performance and use of the reliability models and predictions. Consideration shall be given to the requirements to perform and use the reliability models and predictions in support of a reliability program in accordance with MIL-STD-785, maintainability program in accordance with MIL-STD-470, safety program in accordance with MIL-STD-882, survivability and vulnerability program in accordance with MIL-STD-2072, logistics support analysis in accordance with MIL-STD-1388, maintenance plan analysis (MPA) in accordance with MIL-STD-2080, fault diagrams analysis in general accordance with MIL-STD-1591, and other contractual provisions."

In this paragraph alone, eight standards are mentioned, most of which have some testability/diagnostic implications. Add to this list a number of other standards, such as MIL-STDs 415, 1519, 1326, 2076, 1843, and 2077 and the problem is intensified. Assuming there is a chronological order in the application of these standards and the products they produce, if a link in the chain breaks, the process is no longer applicable. It is no wonder that often the produced products (e. g., FMEAs, TRDs, and LSARs) become merely data deliveries to the government and provide little in-

put to the system engineering process. If the producer of these products can see no urgent requirement, his delivery reflects this perception.

The same is true of guidance information. There are guidance documents which are written for each of the diagnostic elements (e. g., testability, ATE), but at present none that completely promote cohesiveness of the diagnostic design process.

- o Effects of New Weapon System Architectures.

New weapon system architecture, which incorporates dynamic reconfigurability, complex redundancy, and graceful degradation, such as that which is depicted in the Joint Integrated Avionics Plan, requires a rethinking of the standards and guidance used in the diagnostic design process. The diagnostic design must relate to the mission profile and the relevant repair and operational strategies.

- o Effects of Advanced Technologies.

A host of new or integrated technologies will have a major effect on the documentation requirements. Artificial intelligence applications to such diagnostic elements as expert systems and smart BIT will require a re-look at some well-established processes and procedures. The operational scenario of a system which "learns" and whose software is modified in real-time is an example. Whether or not to utilize present configuration management principles as this software changes, and utilize this same software for other aircraft "tail" numbers, other LRUs, etc., must be addressed. Standardization of languages utilized to develop such diagnostic programs and methods for generating technical information must be considered. Electronic delivery of technical information and the display of this information for maintenance and training purposes requires standard approaches. VLSI and VHSIC present more complex support problems. The integration of diagnostic elements, such as are proposed in the Integrated Maintenance Information System (IMIS) require design guidance.

Other existing technologies, which are not adequately addressed by present standards, are performance monitoring and in-flight monitoring, prognostics and preventive maintenance, man/machine interfaces, and sensor technology.

- Test, Evaluation, and Maturation.

Effective development of a diagnostic capability requires that testing and evaluation of this capability proceed concurrently with weapon system development, in an orderly and planned time-phased manner. It is also necessary that a goal be established to provide evaluation of the entire diagnostic capability at the time the prime system demonstrations, test, and evaluations occur. Maturation of this diagnostic capability must be an integral part of the diagnostic demonstration process.

The foundation for diagnostic demonstrations is located in the System Specification. Not only must the means for demonstrating the diagnostic capability be established at that time, but the definition of a failure must also be established. When demonstrating graceful degradation through fault-tolerant design, reconfigurability, redundancy, and performance monitoring, a failure may be defined as causing the mission and performance requirements of the prime system to be compromised. This definition of failure then becomes an important part in the demonstration process.

Another aspect which is recommended be introduced is that of diagnostic growth, similar in concept to the already established reliability growth, except with an entirely different means for specifying and demonstrating this growth. This diagnostic growth is an integral part of the maturation process. Some combination of statistical methods, test analyze and fix, and contractual incentives can be used to implement this concept. GFE and CFE require additional attention during this maturation period. The statement of requirements for these items must be verified and, if not satisfying those requirements, alternative solutions must be provided.

Demonstration programs are required for logistics, reliability, maintainability, human engineering, etc. The standards urge that each of these demonstrations take advantage of the others. However, more needs to be done to assure these various demonstrations take advantage of one another and effect combinations when feasible.

- o Data Collection and Analysis.

The major programmatic standards require that a Data Collection and Analysis of their program be established and pursued. This reporting, tracking, and measurement of the diagnostic capability performance is required throughout the length of the contract and is an integral part of the diagnostic maturation process. With the exception of MIL-STD-1388-2, there is little or no information on what and how data is collected. Although many Air Force data systems exist or are in the planning stages, none satisfy the total diagnostic requirement. Not only is this data required to measure the performance of the diagnostic capability, but it provides firm baseline data for the design of the next generation of prime systems. Means must also be established to assure compatibility between contractor-generated data bases and service data bases.

B. Recommendations.

These key findings and conclusions are reflected in the 24 Document Improvement Reports located at the end of this section. It is recommended that these improvements be initiated by the appropriate DoD preparing activities. As indicated previously, this report contains no recommendations for preparing new documents, with the exception of guidance for implementing the integrated diagnostic process. Rather, emphasis was placed on modification and consolidation of existing documents. Critical to the implementation of this document improvements are the following three recommendations:

- Programmatic Diagnostic Standard.

  There is no question that a programmatic standard is required, which addresses the entire testability/diagnostic program. MIL-STD-2165, Testability Program for Electronic Systems and Equipments, presently addresses many of these requirements. No new standard is proposed. It is recommended that this standard be expanded to cover not only the design characteristics of the weapon system itself (e. g., testability), but other diagnostic elements which constitute the diagnostic capability. The standard would no longer be limited to just electronics, but would address the entire weapon system. The intent is to strengthen the design and integration portion of the present standard, while lessening the requirements for program monitoring and control, and test and evaluation by utilizing other existing standards to perform these functions.

- Design Criteria Standard.

  As cited above, there are a number of standards which control the diagnostic design process. A number of these standards either fully or partially address diagnostic design criteria. This design criteria is fractionated and often obsolete. MIL-STD-415D, although grossly outdated, currently addresses design criteria for test provisions for electronic systems. It is recommended that this standard be completely rewritten and expanded to address new technologies, new system architectures, and the weapon system's entire diagnostic capability.

- Technical Reviews and Audit Standard.

  The appendices to MIL-STD-1521B describe the requirements for the conduct of technical reviews and audits on systems, equipments, and computer software. These appendices are in the form of checklists, which contain the purpose of the particular technical review/audit and a list of items to be reviewed at each one. This standard is only partially complete, in relation to testability and diagnostics. Since this standard is the only guidance available for use during these various

technical reviews and audits, it is important that it be updated to provide reviewers with appropriate guidance.

In addition, the following two recommendations are important.

- o Terminology Standard.

  Standardization of terms used in the fields of testability and diagnostics is important in the specification and implementation of testability and diagnostics. There is a lack of standardization and thus in the understanding of these terms. Presently, there are two standards which are dedicated to defining diagnostic and testability terms. They are MIL-STDs 721 and 1309. MIL-STD-721 best fills the need for standardization terms, but it should be expanded to cover an additional 54 terms. It is also recommended that MIL-STD-1309 be retained as a dictionary of words which are either not preferred or are less pertinent.

- o Obsolete Standards.

  During the course of this program it became apparent that a number of standards were either in the process of becoming obsolete, were already obsolete, or would become obsolete the recommended modification to present standards were implemented. It is proposed that the following five standards either be canceled or not used.

MIL-STD-1326	--	Test Point, Test Point Selection and Interface Requirements for Equipments Monitored by Shipboard On-Line Automatic Test Equipment
MIL-STD-2076	--	Unit Under Test Compatibility With Automatic Test Equipment, General Requirements For
MIL-STD-2084(AS)	--	Maintainability of Avionic and Electronic Syustems and Equipment, General Requirements For

MIL-STD-2080A -- Maintenance Plan Analysis for Aircraft and Ground Support Equipment

DOD-STD-1701 -- Hardware Diagnostic Test Systems Requirements

In addition, consolidation of MIL-STD-1519 (Test Requirements Documents, Preparation Of) and MIL-STD-1345 (Test Requirements Document, Preparation Of) is proposed.

DOCUMENT IMPROVEMENT REPORTS

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 1

REQUIREMENT TITLE: ESTABLISHING DIAGNOSTIC REQUIREMENTS AND ALLOCATING THESE REQUIREMENTS FOR SYSTEM, SUBSYSTEM, AND UNIT LEVELS

DOCUMENT NUMBER: MIL-STD-756B

TITLE: RELIABILITY MODELING AND PREDICTION

EXISTING: X PLANNED:

STANDARDIZATION AREA: RELIABILITY

PREPARING ACTIVITY: NAVAIR 51122, WASHINGTON, D. C.
JOHN COOK, NAEC, 201-323-7458

DOCUMENT PURPOSE:

This standard establishes uniform procedures and ground rules for the preparation of mission reliability and basic reliability models and predictions for electronic, electrical, electromechanical, mechanical, and ordnance systems and equipment. A mission reliability prediction estimates the probability that an item will perform its required functions during the mission period.

TESTABILITY/DIAGNOSTIC IMPACT:

MIL-STD-756B has a major impact on testability and diagnostics. The standard defines mission reliability equations which are key to testability and diagnostic tradeoff decisions. Introduction of diagnostics via a system engineering approach mandates that mission measures be used to provide criteria for tradeoffs. MIL-STD-756B is an important standard in that it defines the reliability in terms of mission reliability, as well as unit reliability at the subsystem level. Testability parameters, such as partitioning, observability, and controllability will influence these reliability decisions.

GENERAL RECOMMENDATIONS:

The methodology to be incorporated into MIL-STD-756B should include the capability to analyze all modern equipment configurations. This should address the following:

- o Complex redundancy, reconfigurable elements, and configurations which allow for graceful degradation
- o The capability to perform the aforementioned analyses through all phases of a mission profile, utilizing impacts of these relevant repair and operational strategies
- o The capability for analyses to be sensitive to all testability/diagnostic parameters, including those generated by BIT and embedded support, such as false alarms and on-line fault detection.

SPECIFIC MODIFICATIONS:

Reliability modeling and prediction must support tradeoffs and assessment of the impact of the dignostic elements on overall weapon system reliability. Current mission reliability models deal well with effectiveness measures over mission time demands and handle complex systems which take into account redundancy. MIL-STD-756B outlines the mathematics which can be used for manually generating these models. Its information is generic and provides a basis for current models and for addressing reconfigurability.

The standard is not sensitive to testability and diagnostics parameters in that these parameters affect the extent to which a system is initially degraded due to undetected or unrepaired failures from preceding missions and the extent to which a failure can be corrected during a mission.

With the emergence of VHSIC technology, new prime system architectures focus on extremely complex designs which allow continued operations, with full capability over mission times by "reconfigurability" of the line replaceable modules (LRM). In other words, systems are being designed to be "fault tolerant" in that they allow a percentage of failures before the unit is considered to fail. The extent to which these faults can be detected, diagnosed, and corrected can have a major impact on the success of the next mission.

To address these needs, three basic changes to MIL-STD-756B are recommended: incorporation of information for repeated mission reliability modeling, information about the mathematics for transitions from mission phase to mission phase, including an equipment turn-around phase, and information about modeling testability/diagnostics-related repair or replacement. The changes are outlined below:

TASK SECTION 100 RECOMMENDATIONS

Insert paragraph 2.2A:

2.2A Repeated Mission Reliability Model. A paragraph defining a model which incorporates testability and diagnostic elements impacts on mission success, also taking into account fault detection and repair during the previous mission and the turn-around time between missions.

Insert paragraph 2.3.9:

2.3.9 Reconfigurable and Complex Mission Requirements. A paragraph identifying how and where to describe mission reliability requirements which are not representable as series and parallel blocks in a block diagram.

Insert paragraph 2.5:

2.5 Computing the Impact of Testability and Diagnostic Parameters. A paragraph describing what testability factors could be used in computing Repeated Mission Reliability and describing how to incorporate them in a Repeated Mission Reliability Model.

TASK SECTION 102 RECOMMENDATIONS

Insert paragraph 3.5:

3.5 The contractor shall develop and maintain a Repeated Mission Reliability Model for each configured item required to perform the mission functions. One or more paragraphs shall elaborate on the traceability of information, consistency of nomenclature, capability, and other aspects of the Repeated Mission Reliability Model.

METHOD 1001 RECOMMENDATIONS

Insert paragraph 2.3:

2.3 Fault Detection, Diagnostics, and Repair. One or more paragraphs that provide the underlying equations to be used in accounting for testability and diagnostic impacts, both during a mission and during a turn-around period between missions in order to be able to compute Repeated Mission Reliability.

METHOD 1002 RECOMMENDATIONS

Insert paragraph 2.3:

2.3 Fault Detection, Diagnostics, and Repair. One or more paragraphs that provide the underlying equations to be used in accounting for testability and diagnostic impacts, both during a mission and during a turn-around period between missions in order to be able to compute Repeated Mission Reliability.

METHOD 1003 RECOMMENDATIONS

Insert paragraph 2.3:

2.3 Fault Detection, Diagnostics, and Repair. One or more paragraphs that provide the underlying equations to be used in accounting for testability and diagnostic impacts, both during a mission and during a turn-around period between missions, in order to be able to compute Repeated Mission Reliability.

METHOD 1004 RECOMMENDATIONS

Insert paragraph 2.3:

2.3 Fault Detection, Diagnostics, and Repair. One or more paragraphs that provide the underlying equations to be used in accounting for testability and diagnostic impacts, both during a mission and during a turn-around period between missions, in order to be able to compute Repeated Mission Reliability.

METHOD 1005 RECOMMENDATIONS

Insert Methods Section 1005:

METHOD 1005 MISSION PHASE TRANSITIONS AND SYSTEM HIERARCHY. A section that provides the procedures for computing the initial conditions of each new phase from the preceding phase and for using the different computation methods in modeling a systems hierarchy from component, to module, to box, to subsystem, to system.

REPEATED MISSION RELIABILITY PREDICTION

Insert Section 203, Repeated Mission Reliability Prediction:

TASK 203 REPEATED MISSION RELIABILITY PREDICTION. Several paragraphs identifying its purpose and rational and giving requirements to be satisfied in its development. It should emphasize the model's use in relating testability and diagnostic requirements to mission needs and in validating testability and diagnostic allocations.

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 1

REQUIREMENT TITLE: ESTABLISHING DIAGNOSTIC REQUIREMENTS AND ALLOCATING THESE REQUIREMENTS FOR SYSTEM, SUBSYSTEM, AND UNIT LEVELS

DOCUMENT NUMBER: MIL-STD-1591

TITLE: ANALYSIS/SYNTHESIS OF ON-AIRCRAFT, FAULT DIAGNOSIS, SUBSYSTEMS

EXISTING: X PLANNED:

STANDARDIZATION AREA: MISCELLANEOUS

PREPARING ACTIVITY: RADC/RBE-2, ROME, NY
DAVE GARAFALO, 315-330-3476

DOCUMENT PURPOSE:

The purpose of MIL-STD-1591 is to provide uniform criteria for conducting trade studies for determining optimum design for on-aircraft fault detection/isolation systems.

TESTABILITY/DIAGNOSTIC IMPACT:

MIL-STD-1591 is a key document because it is the only document which attempts to define this type of trade-off procedure. At this time, no adequate trade-off procedure or allocation techniques exist which are based upon mission needs.

GENERAL RECOMMENDATIONS:

This should be a companion document to MIL-STD-756. When modified, MIL-STD-756 will translate weapon system mission requirements into diagnostic requirements and will serve to allocate these requirements down to each diagnostic element. There is a need to relate these allocations to cost and manpower. At present, MIL-STD-1591 is aimed at optimizing the design for on-aircraft fault detection/isolation. The recently completed RADC task, Tools for Integrated Diagnostics, lays the groundwork for an

initial "most" cost-effective diagnostic mix and provides a general method for assessing the cost and effectiveness of the diagnostic mix as the design progresses throughout the Full-Scale Development Phase. The diagnostic mix, in this case, is composed of built-in, external, and manual resources for an electronic system.

There is no question that more research and development is required to deal with this trade-off function prior to revision of this MIL-STD. Major emphasis in this RDT&E effort should consider the following:

- o Trade-off procedures which address all diagnostic elements (i. e., testing, training, and technical information)
- o Trade-off methodologies which can be applied throughout weapon system development
- o Trade-off methodologies which address all types of weapon systems and both electronic and non-electronic applications.

In addition, the NSIA Integrated Diagnostics Group recommended that this type document be issued as a handbook, since the trade-off methodologies need not be mandatory, but rather for guidance.

SPECIFIC MODIFICATIONS:

As cited above, more research and development effort is required in relation to trade-off procedures and methods. The military services are presently supporting work in this area, and they plan to sponsor additional work in the near future. It is suggested that modifications to MIL-STD-1591 be postponed until sufficient work has been completed to permit substantial improvements in this standard. This will provide RADC with the necessary basis for an integrated trade-off procedures document.

An outline of recommended changes to MIL-STD-1591 follows. These changes expand the scope of the document from aircraft to generic systems, fit the application of this document into the framework of MIL-STD-2165, satisfy mission needs and constraints through application of the revised MIL-STD-756B, and expand the scope of the model to take into account all elements of each alternative diagnostic capability. These changes are outline below:

Modify paragraph 1.1, Purpose

The purpose of the document should be expanded to address the entire diagnostic capability, not just on-aircraft diagnostics.

Modify paragraph 1.2, Application

This paragraph should be modified to address the entire diagnostic capability at all maintenance levels.

Modify paragraph 2.1,

This paragraph should reference MIL-STD-2165 and MIL-STD-756B.

Modify Section 3, Definitions and Abbreviations

The aircraft-specific terms and definitions should be replaced by generic words and definitions. The list of terms should be expanded to encompass all fault detection and diagnostic components used for weapon system operation.

Modify paragraph 4.1, Required Parameters

This paragraph should identify additional areas of consideration related to repeated mission reliability, mission resource constraints (volume, power, manpower, etc.), and impact on each level of maintenance.

Modify paragraph 4.2, Sequence of Work

This paragraph should be modified to properly introduce computations of repeated mission reliability, needed resources, and impacts on each level of maintenance. This modification should specify that alternatives which are unacceptable for meeting any of the

mission requirements, or which exceed resources that can be made available for operation, must be removed from consideration before the cost analysis is done.

Modify paragraph 5.1, Determination of Conceptual Options

This paragraph should describe additional areas of consideration related to repeated mission reliability, mission resource constraints (volume, power, manpower, etc.), and impacts on each level of maintenance. It must be expanded to encompass all fault detection and diagnostics-related considerations.

Modify paragraph 5.2, Selection of Best Conceptual Option

This paragraph needs to identify the other parameters besides cost which affect the selection decision and describe the computations or reference documents describing the computations (e. g., MIL-STD-756B).

The paragraph 5.2 cost model must be generalized to encompass all fault detection and diagnostic elements used for system operation and extended to address costs other than the maintenance manpower and support equipment, which are currently considered. Training, technical information, spares, and other maintenance-level workloads need to be considered.

Modify paragraph 5.3, Procedure for Synthesizing Detail Design of the Selected OBBIT Concept

This paragraph needs to be modified to expand OBBIT design drivers from relative fault frequency and detection costs to include mission criticality and survivability factors.

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.:	1
REQUIREMENT TITLE:	ESTABLISHING DIAGNOSTIC REQUIREMENTS AND ALLOCATING THESE REQUIREMENTS FOR SYSTEM, SUBSYSTEM, AND UNIT LEVELS
DOCUMENT NUMBER:	MIL-STD-490A
TITLE:	SPECIFICATION PRACTICES
EXISTING: X	PLANNED:
STANDARDIZATION AREA:	CMAN
PREPARING ACTIVITY:	HQ AFSC/PLEQ, ANDREWS AFB, WASHINGTON, D. C. 301-981-2751

DOCUMENT PURPOSE:

The purpose of this standard is to establish uniform practices for specification preparation, to ensure the inclusion of essential requirements, and to aid in the use and analysis of specification content.

TESTABILITY/DIAGNOSTIC IMPACT:

The specifications stated in the various appendices and DIDs establish the requirement for specifying the configuration item functional baseline, allocated baseline, and product baseline. Diagnostic elements are part of the baselines and must be defined in the applicable specifications.

GENERAL RECOMMENDATIONS:

For the Prime Item Development, the Critical Item Development, and System/Segment Specifications, it is recommended that a paragraph labeled "Diagnostics" be included in each Section 3.

SPECIFIC MODIFICATIONS:

Page 56, Appendix II, Type B1, Prime Item Development Specification, after Section 20.3.2.2.4C, add the following:

"20.3.2.4.1 Paragraph 3.2.4.1 Diagnostics. The paragraph shall specify the quantitative diagnostic capability requirements. The requirements shall apply to diagnostic elements at all planned maintenance levels. Examples of the diagnostic elements are:

- o Configuration item design requirements for BIT/ Testability
- o Configuration item FD/FI level quantification
- o Off-equipment diagnostic parametric quantification in terms of automatic test equipment/test program sets and manual test equipment performance requirements."

Page 64, Appendix III, Type B2, Critical Item Development Specification, after paragraph 30.3.2.4, add the following:

"30.3.2.4.1 Paragraph 3.2.4.1 Diagnostics. This paragraph shall specify the quantitative diagnostic capability requirements. The requirements shall apply to diagnostic capability in the planned operational, maintenance, and support environments and shall be stated in diagnostic capability quantitative parametric terms."

Page 48, DI-CMAN-80008, System/Segment Specification, paragraph 6.2, make the following changes:

Page 20, insert new Paragraph 10.2.5.4.2.2, "Diagnostics" and renumber each subsequent paragraph, beginning with existing paragraph 10.2.5.4.2.2 in sequence. Each paragraph number stated in the first sentence of each of the above-mentioned paragraphs must also be increased by one integer in last column.

Add new paragraph as follows: 10.2.5.4.2.2 "Diagnostics." This subparagraph shall be numbered 3.4.2.2 and shall specify quantitative system diagnostic requirements. The requirements shall apply to diagnostics in the

operational mode during mission performance, to O-Level maintenance onboard the system and off-equipment requirements at the O-I-D levels of maintenance. Examples are:

(a) Status monitoring requirements during system operation

(b) Fault detection/fault isolation levels onboard

(c) Fault detection/fault isolation levels equipment at each maintenance level."

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 2

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: MIL-STD-499A

TITLE: ENGINEERING MANAGEMENT

EXISTING: X PLANNED:

STANDARDIZATION AREA: MISCELLANEOUS

PREPARING ACTIVITY: HQ AFSC/PLEQ, ANDREWS AFB, WASHINGTON, D. C.
CAPT. SYLVESTER, 301-981-2751
HQ AFSC/SDX, ANDREWS AFB, WASHINGTON, D. C.
MAJ. KEN MILLER, 301-981-3316

DOCUMENT PURPOSE:

This standard provides the program manager with:

(a) Criteria for evaluating engineering planning and output

(b) A means for establishing an engineering effort and a System Engineering Management Plan (SEMP)

(c) Task statements that may be selectively applies to an acquisition program.

TESTABILITY/DIAGNOSTIC IMPACT:

The effective implementation of the Integrated Diagnostic process is accomplished through the inclusion of diagnostic requirements in the SEMP. Since MIL-STD-499A provides a means for establishing an engineering effort and a SEMP, the success of diagnostic implementation is dependent on the proper implementation of the requirements stated in MIL-STD-499A.

GENERAL RECOMMENDATIONS:

MIL-STD-499A is a generic standard written so that it defines a systems engineering management process that is applicable to weapon systems, subsystems (electronics, engines, support equipment) and equipment. Testability and diagnostic requirements, while not specifically addressed in the standard, are included through interpretation as part of the system engineering and engineering specialty process. In order to provide needed visibility within the standard, it is recommended that the word "diagnostics" be inserted into the MIL-STD-499A text, as stated below: These insertions do not impact the intent or the requirements of the standard.

SPECIFIC MODIFICATIONS:

Page 3, paragraph 3.4: In the first sentence, between the words "maintainability," and "logistics", insert "diagnostics,".

Page 4, paragraph (d): After the word "Maintainability," insert "Diagnostics,".

Page 5, paragraph (n): Between the words "transportability" and "reliability", insert "diagnostics,".

Page 8, paragraph 6.3: Seventh (7th) sentence, after the word "ownership", insert ", diagnostics,".

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 2

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: MIL-STD-1388-1A

TITLE: LOGISTICS SUPPORT ANALYSIS

EXISTING: X PLANNED:

STANDARDIZATION AREA: MISCELLANEOUS

PREPARING ACTIVITY: ARMY, AMXMD-EL, LEXINGTON, KY
JIM CRABTREE, 606-293-3962
ROBERT SHIELD, 606-293-3962

DOCUMENT PURPOSE:

The purpose of MIL-STD-1388-1A, the Logistic Support Analysis process, is to define the programmatic requirements for performing support and supportability tradeoffs in the weapon system development process. The LSA is a systematic and comprehensive analysis, conducted on an iterative basis through all phases of the system/equipment life cycle to satisfy supportability objectives.

TESTABILITY/DIAGNOSTIC IMPACT:

Proper implementation of the LSA process should include an emphasis on testability and diagnostic requirements, because a comprehensive diagnostic capability may decrease shortfalls and unnecessary burdens on the logistics support structure. It is necessary to consider testability and diagnostic considerations in the LSA process.

GENERAL RECOMMENDATIONS:

MIL-STD-1388-1A does address the subject of testability and diagnostics, but only in a cursory manner. MIL-STD-1388 contains the framework for the necessary analyses to be conducted, but does not house the specific details or level of emphasis required for a comprehensive analysis relating to testability and diagnostics. It is recommended, therefore, that the emphasis be placed in a document solely dedicated to diagnostics (i. e., MIL-STD-2165 Revised) and that MIL-STD-1388 undergo minor revisions to increase the inclusion of diagnostics considerations in the logistics tradeoffs conducted. A strong relationship, with specific interfaces, between the diagnostics standard and the LSA standard should be established and defined.

SPECIFIC MODIFICATIONS:

Section 2.1: Include "MIL-STD-2165, Testability Program for Electronic Systems and Equipments," in the referenced document list.

Task 303, 303.2.8: Insert "maintenance aiding," after "automatic testing,".

Task 401, 401.2.3: After the words "support and test equipment,", add the words "maintenance aids,".

Task 402, 402.2.1: After the words "automatic test equipment,", add the words "and test program sets".

Appendix A, paragraph 50.3.4.2c: Replace the words "Maintainability Program" with "Diagnostics/Testability Program (MIL-STD-2165)".

Appendix A, paragraph 50.4.2d: After the words "test program sets (TPS)", add the words "and maintenance aids".

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 2

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: MIL-STD-785B

TITLE: RELIABILITY PROGRAM FOR SYSTEMS AND EQUIPMENT DEVELOPMENT AND PRODUCTION

EXISTING: X PLANNED:

STANDARDIZATION AREA: RELIABILITY

PREPARING ACTIVITY: ASD/ENES, WRIGHT-PATTERSON AFB, DAYTON, OH
MARY COURY, 513-255-6295

DOCUMENT PURPOSE:

This standard provides general requirements and specific tasks for reliability programs during the development, production, and initial deployment of systems and equipment.

TESTABILITY/DIAGNOSTIC IMPACT:

A weapon system's reliability program forms the basis for maintainability, testability, and diagnostic programs. Fault-tolerant design and dynamic reconfigurability are the basis for deferred maintenance and thus play a large part in determining testability and diagnostic requirements. The failure modes and effects analyses, which are a substantial portion of a reliability program, provide a significant input to diagnostic and test functions by identifying likely ways in which a system can fail and the criticality of a given failure. Throughout reliability design, testing, and demonstration, this diagnostic capability shall not only be included as part of the prime system, but should be evaluated in terms of its troubleshooting capability (i. e., ability to fault detect and fault isolate).

GENERAL RECOMMENDATIONS:

At present, MIL-STD-785B does not implement MIL-STD-756, Reliability Modeling and Prediction. Included in MIL-STD-756 are mission reliability modeling techniques which can be applied during Concept Exploration and Demonstration and Validation Phases as a means for translating weapon system mission and performance requirements into reliability, maintainability, testability, and diagnostic requirements. In addition, the standard does specifically address the reliability of the diagnostic capability.

SPECIFIC MODIFICATIONS:

Add paragraph 1.4, Embedded Diagnostics. The term "system and equipment" includes the reliability of the embedded diagnostic capability (e. g., built-in test, maintenance aiding and training). Therefore, the reliability program described in this standard includes the embedded diagnostic capability as an integral part of the prime systems and equipment.

Paragraph 2.1: Add "MIL-STD-756, Reliability Modeling and Prediction" to Standards, Military Documents.

Task 201, paragraph 201.2.3: Replace the words "Appendix A of MIL-HDBK-217" with "MIL-STD-756".

Task 204 and paragraph 50.2.3.1.2, Appendix A: These tasks should recognize that FMECA can be used as a BIT design tool. Revise paragraph 204.2.2 to insert the words "designing and" in front of the words "evaluating the effectiveness of built-in test,".

Paragraph 50.2.3.1.2: Replace the last sentence of this paragraph to read as follows:

"FMECA is an effective tool for designing the diagnostic capability for it is initial step in generating diagnostic and test programs. FMECA is also an effective tool for evaluating the effectiveness of built-in test."

Paragraph 50.1.3.1.3: After the word "maintainability," insert "diagnostics, testability,".

Paragraph 50.2.4.1.1: This paragraph should be written to alert the reader that diagnostics plays a key role in fault-tolerant design for it provides for graceful degradation, which lessens the need for immediate corrective maintenance. However, this does not lessen the need for accurate and timely fault detection and isolation. This can be accomplished by adding the words: "including the design of the diagnostic capability which is required to reconfigure the system and to isolate the failed unit when corrective maintenance is accomplished", after the words, "Criteria such as these influence the design and operation of almost all subsystems,".

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 2

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: MIL-STD-470A

TITLE: MAINTAINABILITY PROGRAM REQUIREMENTS (FOR SYSTEMS AND EQUIPMENT)

EXISTING: X PLANNED:

STANDARDIZATION AREA: MAINTAINABILITY

PREPARING ACTIVITY: RADC/RBE-2, ROME, NY
JERRY KLION, 315-330-4726

DOCUMENT PURPOSE:

This standard provides task descriptions for maintainability programs.

TESTABILITY/DIAGNOSTIC IMPACT:

This standard is very closely allied to MIL-STD-2165, Testability Program for Electronic Systems and Equipments. Inasmuch as this report recommends the strengthening of the Task 200 series in MIL-STD-2165, the proposed modifications to MIL-STD-470A are minor.

GENERAL RECOMMENDATIONS:

Cross-referencing with MIL-STD-2165 is required to assure compatibility.

SPECIFIC MODIFICATIONS:

Paragraph 2.1: Add "MIL-STD-2165, Testability Program for Electronic Systems and Equipments" to standards, military documents.

Paragraph 4.1.1: Before the last sentence, add "Testability Program Requirements for Electronic Systems and Equipments (MIL-STD-2165), in particular, have a significant interface with a majority of tasks identified in this standard."

Task 101, paragraph 101.2.1f: After each use of the word "maintainability,", add the words "testability and diagnostics".

Task 103, paragraph 103.2.2: Add the following to the reviews --

"At System Requirements Review:

Results of trade studies leading to Preliminary System Design Concept."

"At System Design Review:

(1) Diagnostic Content of Development Specification
(2) Diagnostic Maturation and Data Collection Plan
(3) System Optimization Tradeoffs
(4) Risk Analysis
(5) Diagnostic allocation."

"At Production Readiness Review:

Results of Evaluation of Entire Diagnostic Capability."

Task 103, paragraph 103.2.2b, at the Critical Design Review (CDR), as a last item in that paragraph, add, "(10) Inherent Testability Assessment."

Task 104, General: Add the words "and diagnostics" after each time "maintainability" is used.

Task 104, paragraph 104.3.1b: Replace the word "test" with "diagnostics".

Task 202, paragraph 202.2.1: Add the following sentence to the end of the paragraph: "Inputs from Task 201, MIL-STD-2165, form the basis for diagnostic allocation."

Task 205, paragraph 205.2.1: Add the following sentence to the end of the paragraph: "Inputs from Task 202, MIL-STD-2165, will form the basis for testability and diagnostic analysis."

Task 205, paragraph 205.2.2.6: To further elaborate on the items to be considered during Maintainability Analysis, the paragraph should read as follows: "Mixes of automatic, semi-automatic, built-in and manual test, maintenance aids, manual diagnostic procedures at all levels of repair and their associated software and technical costs, skill levels required and manpower requirements, and acquisition costs."

Task 206, paragraph 206.2.2.3(h): The list of guidelines and policies supplied in Maintainability Design need to be clarified and expanded. Delete and replace, with:

"(h) Testability and fault-tolerant design techniques."

Task 206, paragraph 206.2.2.3: Add (n), which reads:

"(n) Interface with computer-aided engineering and computer-aided design techniques."

Task 301, paragraph 301.2.2(g): After the words "secondary failures," insert "effectiveness of the diagnostic capability".

APPENDIX A:

Table A-1, Application Matrix. If Task 202, Maintainability Allocations, is to include testability and diagnostic allocations, then the general usage (g), cited in Table A-1, should also be applied during the Demonstration and Validation Phase.

Paragraph 40.1.5.1.1f.: After the word "maintainability," add the words "and diagnostics".

Paragraph 40.2.5.2: After each time the word "test" is used, add the words "and diagnostic". Also add subparagraph as follows:

"(h) Maintenance aiding and other diagnostic procedures."

Paragraph 40.2.5.2.6(new): Insert this paragraph after 40.2.5.2.5 and renumber subsequent paragraphs accordingly:

"40.2.5.2.6 The use of maintenance aids, including diagnostic routines, repair procedures, and maintenance historical data provide a powerful tool when combined with a test capability. The potential exists to provide 100% fault detection/fault isolation capability."

Paragraph 40.2.6.2a: Add the following:

"(7) Testability and fault-tolerant design."

Paragraph 40.3.1.8: After item "e.", add the following item "f" and reletter the present "f" and "g" accordingly.

"f. Diagnostic Capability Demonstrations. In accordance with MIL-STD-2165, the testability demonstration is to be performed as part of the maintainability demonstrations. Thus the ground rules for the MD should address all elements that make up the diagnostic capability (i. e., testing, technical information, personnel, and training) that are required to meet fault detection and isolation requirements. This includes continuity, consistency, and compatibility of the diagnostic capability between maintenance levels."

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 2

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: MIL-STD-2165

TITLE: TESTABILITY PROGRAM FOR ELECTRONIC SYSTEMS AND EQUIPMENTS

EXISTING: X PLANNED:

STANDARDIZATION AREA: ATTS/MNTY

PREPARING ACTIVITY: NAVSEA, WASHINGTON, D. C. PAUL GROSS, 202-692-2035

DOCUMENT PURPOSE:

The standard provides uniform procedures and methods for establishing a testability program, for assessing testability in designs, and for integration of testability into the acquisition process for electronic systems and equipment. Expansion of the document's scope is proposed to cover the entire weapon system's diagnostic capability, including design characteristics of the weapon system itself and associated testing, technical information, and personnel and training.

TESTABILITY/DIAGNOSTIC IMPACT:

This standard will be the prime programmatic document for controlling the acquisition of a weapon system's diagnostic capability.

GENERAL RECOMMENDATIONS:

It is proposed that this standard be expanded to cover the design characteristics of the weapon system itself (e. g., fault tolerant design) and other diagnostic elements that constitute the diagnostic capability. The standard will no longer be limited to just electronics, but will ad-

dress the entire weapon system. Therefore, the title should be changed to "Testability/Diagnostic Program Requirements for Systems, Subsystems, and Equipments." The intent is to strengthen the design and integration portion of the present standard, while lessening the requirements for program monitoring and control, and test and evaluation by utilizing other existing standards to perform these functions. In addition, when MIL-STD-415 is revised to address design criteria for the entire diagnostic capability, it must be referenced at appropriate places in MIL-STD-2165.

SPECIFIC MODIFICATIONS:

Substantial modifications follow, many times requiring a complete rewrite of sections and paragraphs.

1. SCOPE

1.1 Purpose

This standard provides uniform procedures and methods for establishing a program for acquiring a weapon system's diagnostic capability, for assessing this capability and design, and for integration of all of the elements which constitute this capability into the acquisition process.

1.2 Application

This standard is applicable to the development of all types of weapon systems, subsystems, and equipments for the Department of Defense. Appropriate tasks of this standard are to be applied during the Concept Exploration Phase, Demonstration and Validation Phase, Full-Scale Development Phase, and Production/Deployment Phase of the system acquisition process.

3. DEFINITIONS AND ACRONYMS

3.1 Definitions

The definitions included in MIL-STD-1309 and MIL-STD-721 shall apply. In addition, the definitions of Appendix C are applicable.

4. GENERAL REQUIREMENTS

4.1 Scope of Diagnostic Program

This standard is intended to impose and facilitate interdisciplinary efforts required to develop an adequate diagnostic capability for weapon systems and equipments. The program scope includes:

(a) Support of, and integration with, reliability and maintainability design, including retirements for deferred maintenance, performance monitoring, and corrective maintenance action at all levels of maintenance.

(b) Support of integrated logistic support requirements, including the support and test equipment, human engineering, technical publications, training and training equipment, and safety elements.

(c) Support of, and integration with, design engineering requirements, including hierarchical development of testability designs from piece/part to the system.

4.2 Testability Program Requirements

A diagnostic program shall be established which accomplishes the following general requirements:

(a) Establishment of program planning requirements

(b) Establishment of a sufficient, achievable, and affordable weapon system diagnostic capability

(c) Integration of the diagnostic elements that constitute the entire weapon system's diagnostic capability

(d) Evaluation of the extent to which the design meets the diagnostic requirements

(e) Inclusion of diagnostics in the program review process.

4.3 Application of the Requirements

Detailed requirements described in this standard are to be selectively applied and tailored, as required and as appropriate, to particular systems and equipment acquisition programs. Maximum use has been made of reliability, maintainability, logistics, and human engineering program tasks as vehicles for implementing the diagnostic program. Appendix A provides the rationale and guidance for the selection and tailoring of diagnostic program tasks.

5. DETAILED REQUIREMENTS

5.1 Task Descriptions

Individual task requirements are provided for the establishment of a weapon system diagnostic capability program. The tasks are categorized as follows:

TASK SECTION 100. PROGRAM MONITORING AND CONTROL

Task 101, Diagnostic Capability Program Planning
Task 102, Diagnostic Reviews
Task 103, Diagnostic Data Collection and Analysis Planning

TASK SECTION 200. DESIGN AND ANALYSIS

Task 201, Diagnostic Requirements
Task 202, Testability/Diagnostic Preliminary Design and Analysis
Task 203, Testability/Diagnostic Detail Design and Analysis

TASK SECTION 300. TEST AND EVALUATION

Task 301, Diagnostic Inputs to Maintainability Demonstrations

6. NOTES

When this standard is used in an acquisition, the data identified below shall be deliverable only when specified on the DD Form 1423, Contract Data Requirement List (CDRL). When the DD Form 1423 is not used and Defense Acquisition Regulation 7-104.9(n)(2) is cited, the data identified below shall be delivered in accordance with requirements specified

in the contract or purchase order. Deliverable data associated with the requirements of this standard are cited in the following tasks:

TASK	DATA REQUIREMENT	APPLICABLE DATA ITEM DESCRIPTION (DID)
101	Systems Engineering	UDI-E-23974 (1) (2)
102	Diagnostic Reviews	DI-E-5423 (1)
201,202,203	Testability Analysis Report	DI-T-7199
301	Maintainability Demonstration Test Plan	DI-R-7112
	Maintainability Demonstration	DI-R-7113

(1) Equivalent approved DID may be used.

(2) This DID should be tailored to require inclusion of Diagnostic Capability Program Planning in the SEMP.

TASK 101

DIAGNOSTIC CAPABILITY PROGRAM PLANNING

101.1 PURPOSE. To plan for a program which will identify and integrate all design management tasks required to acquire a diagnostic capability for a weapon system.

101.2 TASK DESCRIPTION

101.2.1 Identify a single organizational element within the performing activity which has overall responsibility and authority for implementation of the program. Establish analyses and data interfaces among the organizational elements responsible for each of the elements of the diagnostic capability and other related elements.

101.2.2 Develop a process by which diagnostic requirements are integrated with other design requirements and disseminated to design personnel and subcontractors. Establish controls for assuring that each subcontractor's diagnostic practices are consistent with overall system or equipment requirements.

101.2.3 Identify diagnostic design guides and analysis models and procedures to be imposed upon the design process. Plan for the review, verification, and utilization of diagnostic data submissions.

101.2.4 Develop a Diagnostic Capability Program Plan which describes how the program will be conducted. The program plan shall be included as part of the Systems Engineering Management Plan. The plan describes the time phasing of each task included in the contractual requirements and its relationship to other tasks. Diagnostic issues which relate to reliability, maintainability, logistics, human engineering, safety, etc., should be addressed in those plans.

101.3 TASK INPUT

101.3.1 Identification of each diagnostic task which is required to be performed as part of the program.*

* To be specified by the requiring authority.

101.3.2 Identification of the time period over which each task is to be conducted.*

101.3.3 Identification of approval procedures for plan updates.*

101.3.4 Identification of deliverable data items.*

101.4 TASK OUTPUT

101.4.1 The program plan is to be a part of the System Engineering Management Plan.

* To be specified by the requiring authority.

TASK 102

DIAGNOSTIC REVIEWS

102.1 PURPOSE. To establish a requirement for the performing activity to (1) provide for an official review of diagnostic design information in a timely and controlled manner, and (2) conduct in-process diagnostic design reviews at specified dates to ensure that the program is proceeding in accordance with the contract requirements and program plans.

102.2 TASK DESCRIPTION

102.2.1 Include the formal reviews and assessment of the diagnostic program as an integral part of each system program review (e. g., System Design Review, Preliminary Design Review, Critical Design Review, etc.) specified by the contract. Reviews shall cover all pertinent aspects of the diagnostic program, such as:

(a) Status and results of diagnostic-related tasks

(b) Documentation of task results in the testability analysis report

(c) Diagnostics-related requirements in specifications

(d) Diagnostic design, cost, or schedule problems.

Use MIL-STD-1521, Technical Reviews and Audits for Systems, Equipments, and Computer Programs as guidance for conducting these formal reviews.

102.2.2 Conduct and document diagnostic design reviews with performing activity personnel and with subcontractors and suppliers. Coordinate and conduct diagnostic reviews in conjunction with reliability, maintainability, human engineering, and logistic support reviews, whenever possible. Utilize MIL-STD-1521 and program review criteria contained in MIL-STDs 470, 785, and 1388-1 as guidance.

102.3 TASK INPUT

102.3.1 Identification of amount of time to be devoted to the diagnostic program at each formal review and the level of technical detail to be provided.*

102.3.2 Identification of level of participation desired by the requiring authority in internal and subcontractor diagnostic design reviews.*

102.4 TASK OUTPUT

102.4.1 Documented results of diagnostic assessment as an integral part of system program review documentation. (102.2.1) (See MIL-STD-1521)

102.4.2 Documented results of diagnostic design reviews, including action items pending. (102.2.2)

* To be specified by the requiring authority.

TASK 103

DIAGNOSTIC DATA COLLECTION AND ANALYSIS PLANNING

103.1 PURPOSE. To establish a method for identifying and tracking diagnostic-related problems during system design, production, and deployment and identifying corrective actions.

103.2 TASK DESCRIPTION

103.2.1 Develop a plan for the analysis of test results to determine if BIT hardware and software, ATE hardware and software, maintenance documentation, and manning are meeting specifications in terms of fault detection, fault resolution, fault detection times, and fault isolation times.

103.2.2 Develop a plan for the analysis of maintenance actions for the fielded system to determine if BIT hardware and software, ATE hardware and software, maintenance documentation, and manning are meeting specifications in terms of fault detection, fault resolution, false indications, fault detection times, and fault isolation times.

103.2.3 Define data collection requirements to meet the needs of the testability analysis. The data collected shall include a description of relevant operational anomalies and maintenance actions. Data collection shall be integrated with similar data collection procedures, such as those for reliability and maintainability and logistic support analysis and shall be compatible with specified data systems in use by the military user organization.

103.3 TASK INPUT

103.3.1 Identification of field or depot test equipment (either government-furnished equipment or contractor-furnished equipment) to be available for development, production, and deployment testing.*

* To be specified by the requiring authority.

103.3.2 Identification of existing data collection systems in use by the using command.*

103.3.3 Relationship of Task 103 to Task 104 of MIL-STD-785 and Task 104 of MIL-STD-470.*

103.4 TASK OUTPUT

Utilize data systems established under MIL-STD-785 and MIL-STD-470.

* To be specified by the requiring authority.

TASK 201

DIAGNOSTIC REQUIREMENTS

201.1 PURPOSE. To (1) recommend system diagnostic requirements which best achieve mission performance, availability and supportability requirements, and (2) allocate those requirements to subsystems and items addressing all diagnostic functions (i. e., test equipment, technical publications, personnel, training).

201.2 TASK DESCRIPTION

201.2.1 Establish overall diagnostic design objectives, goals, thresholds, and constraints which support mission requirements and operational constraints in support of the logistic support analysis process of MIL-STD-1388-1A and the system engineering process. Inputs to these requirements include:

(a) Translation of weapon system mission and performance requirements into diagnostic requirements which support the mission scenario.

(b) Establishment of requirements which allow for diagnostic growth as design proceeds through the weapon system acquisition phases.

(c) Identification of diagnostics-related constraints driven by operational constraints of the system.

(d) Identification of technology advancements which can be exploited in system development and diagnostic element development and which have the potential for increasing diagnostic effectiveness; reducing the requirement for maintenance; reducing test equipment, technical manuals and manpower, and skill-level requirements; reducing diagnostics costs; or enhancing system availability.

(e) Identification of existing and planned diagnostic resources (e. g., family of testers, maintenance aids) which have potential benefits. Identify resource limitations.

(f) Identification of diagnostics problems on similar systems which should be avoided.

201.2.2 Define what constitutes a system failure and establish deferred maintenance, performance monitoring, embedded diagnostic, and external diagnostic objectives for the new system at the system and subsystem levels. Identify the risks and uncertainties involved in achieving the objectives established.

201.2.3 Establish BIT, test equipment, technical information, and maintenance manpower and skill-level constraints for the new system for inclusion in system specifications or other requirements documents. These constraints shall include both quantitative and qualitative constraints.

201.2.4 Evaluate alternative diagnostic concepts to include varying degrees of BIT, manual and automatic testing, technical information format and delivery systems, personnel and training, along with deferred, preventive, and scheduled maintenance concepts, and identify the selected concept. The evaluation shall include:

(a) A determination of the sensitivity of system mission performance and readiness parameters to variations in key diagnostic element parameters.

(b) A determination of the sensitivity of life cycle costs to variations in diagnostic element parameters.

(c) An estimation of the manpower and personnel implications of alternative diagnostic concepts in terms of direct maintenance manhours per operating hour, job classification, skill levels, and experience required at each level of maintenance.

(d) An estimation of the risk associated with each concept.

201.2.5 Establish embedded diagnostic requirements, performance requirements, and requirements for monitors and sensors at the system and subsystem level. These requirements include specific numeric performance requirements imposed by the requiring authority. Other requirements shall be based, in part, on:

(a) Maximum allowable time between the occurrence of a failure condition and the detection of the failure for each mission function.

(b) Maximum allowable occurrence of system downtime due to erroneous failure indications (BIT false alarms).

(c) Maximum allowable downtime due to corrective maintenance actions at the Organizational level.

(d) Minimum life cycle costs.

201.2.6 Recommend system diagnostic design provisions, BIT and testability requirements, manual and automatic test, technical information, and personnel and training requirements for inclusion in system specifications. Appendix A, Figure 5, provides guidance on requirements to be specified.

201.2.7 Allocate embedded diagnostics and testability requirements to configuration item specifications, based upon reliability and criticality considerations.

201.2.8 Prepare external diagnostic element specifications.

201.3 TASK INPUT

201.3.1 Supportability analysis data in accordance with MIL-STD-1388-1A or other method approved by the requiring authority.

201.3.2 Reliability and maintainability analysis and requirements, such as from Task 203 of MIL-STD-785 and Task 205 of MIL-STD-470.

201.3.3 Specific numeric diagnostic and testability requirements.*

201.3.4 Human Engineering Analysis and Requirements, such as from MIL-H-46885, paragraph 3.2.1.

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* To be specified by the requiring authority.

201.4 TASK OUTPUT

201.4.1 Diagnostic data required for supportability analysis. (201.2.1 through 201.2.4)

201.4.2 Description of selected diagnostic concept and trade-off methodology, evaluation criteria, models used, and analysis results, documented in accordance with DI-T-7199.

201.4.3 Recommended diagnostic and testability requirements for system specification. (201.2.3 and 201.2.6)

201.4.4 Recommended diagnostic and testability requirements for each configuration item specification. (201.2.7)

201.4.5 Specifications for external diagnostic elements.

TASK 202

TESTABILITY/DIAGNOSTICS PRELIMINARY DESIGN AND ANALYSIS

Incorporate the following modifications:

201.1 PURPOSE. To incorporate testability/diagnostic design practices into design of the system or equipment early in the design phase and to assist the extent to which testability is incorporated.

Renumber 202.2.5 to 202.2.6 and insert the following:

"202.2.5 Determine the impact of the diagnostic parametric values on reliability, maintainability, technical information, manpower, training, and external diagnostics hardware and software."

202.3.4 Human Engineering Analysis, such as from MIL-H-46855, paragraph 3.2.1.3.

Renumber 202.4.5 to 202.4.6 and insert the following:

"202.4.5 Preliminary design for diagnostic-related tradeoffs and optimization, in accordance with DI-T-7199. Develop and document viable alternative diagnostic element concepts (off-line test equipment, technical information)."

TASK 203

TESTABILITY/DIAGNOSTICS DETAIL DESIGN AND ANALYSIS

203.1 PURPOSE. To incorporate the diagnostic capability into the design of a system, equipment, or support equipment which will satisfy diagnostic performance requirements and to predict the level of diagnostic effectiveness which will be achieved for the weapon system or equipment.

203.2 TASK DESCRIPTION

Make the following changes in Task 203.2:

203.2.4 through 203.2.6. Replace the word "BIT" with the words "embedded diagnostics."

203.2.8 Prepare test requirements document, in accordance with MIL-STD-1519.

203.2.9 Develop and define off-line test equipment requirements. (Input to Task 207, MIL-STD-470)

203.2.10 Define test program set requirements.

203.2.11 Determine diagnostic technical information needs and method of delivery of this information. (Input to Task 207, MIL-STD-470)

203.2.12 Determine manpower, training, and training equipment requirements and develop required hardware and software. (Input to Task 207, MIL-STD-470 and Phase I, MIL-STD-1379)

203.2.13 Incorporate testability and diagnostic corrective design actions, as determined by the maintainability demonstration results and initial testing.

203.2.14 Identical to present 203.2.9, except replace the word "BIT" with the words "embedded diagnostics."

203.3.3 Replace "BIT specifications." with "Diagnostic specifications."

203.3.6 Human Engineering Equipment Design, such as from MIL-H-46855, paragraph 3.2.2.

203.4.1 Replace with "System or item design which meets diagnostic and maintainability requirements (203.2.1; 203.2.4; 203.2.5; 203.2.8; 203.2.9; 203.2.10; 203.2.11; 203.2.12; 203.2.13)."

TASK 301

DIAGNOSTIC INPUTS TO MAINTAINABILITY DEMONSTRATIONS

Paragraph 301.1 and 301.2.1: Replace "testability requirements" with "diagnostic requirements".

Paragraph 301.2.2 and 301.2.3: Replace "testability" with "diagnostics".

Delete paragraphs 301.4.1 and 301.4.2 and replace with: "301.4 TASK OUTPUT. Outputs shall be in accordance with MIL-STD-470, Task 301."

APPENDIX A

DIAGNOSTIC PROGRAM APPLICATION GUIDANCE

Major changes will have to be made in Appendix A to reflect the changes in the basic military standard. Major modifications include:

- Revision to the samples specifications, reflecting what is contained in the National Security Industrial Association's "Guidelines for Preparation of Diagnostic Requirements."
- Specific diagnostic inputs to the reliability, maintainability, and logistic program plans.
- Revision of the program flow diagrams and the task application matrix.

The content of Appendix A must be compatible with the Testability Analysis Handbook, which is presently under preparation. Much of the material presently contained in this appendix will be addressed in this handbook. Thus it is important that duplication be minimized when Appendix A is revised. Topics not covered by the handbook should be included, and reference needs to be made to material in the handbook.

APPENDIX C

GLOSSARY

Add additional terms, such as:

- o Diagnostic Capability
- o Diagnostic Element
- o Integrated Diagnostics
- o Embedded Diagnostics
- o External Diagnostics
- o Maintenance Aid
- o Expert Diagnostic System

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.:	2
REQUIREMENT TITLE:	DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION
DOCUMENT NUMBER:	MIL-STD-1629A
TITLE:	PROCEDURES FOR PERFORMING A FAILURE MODE, EFFECTS, AND CRITICALITY ANALYSIS
EXISTING: X	PLANNED:
STANDARDIZATION AREA:	RELIABILITY
PREPARING ACTIVITY:	NAVAIR 5112, WASHINGTON, D. C. JOHN COOK, NAEC, 201-323-7458

DOCUMENT PURPOSE:

To establish requirements and procedures for performing a failure mode, effects, and criticality analysis (FMECA) to systematically evaluate and document, by item failure mode analysis, the potential impact of each functional or hardware failure on mission success, personnel and system safety, system performance, maintainability, and maintenance requirements. Each potential failure is ranked by the severity of its effect in order that appropriate corrective actions may be taken to eliminate or control the high-risk items.

TESTABILITY/DIAGNOSTIC IMPACT:

It is through the FMECA that the diagnostic parametric values can be specified and evaluated for percentage levels, ambiguity size, impact on reliability and maintainability, impact on training and personnel, and impact on system performance and system safety.

GENERAL RECOMMENDATIONS:

At present, no significant changes in this standard are required from a diagnostic perspective. However, Task 103, FMECA--Maintainability Information, is loosely coupled to the diagnostic design process. At present, this coupling is addressed in MIL-STD-2165. Direct coupling is required between Task 103 and the test logic and test point selection process. This can best be accomplished by the proposed revision to MIL-STD-415, which will address this subject.

SPECIFIC MODIFICATIONS:

Delete all references to MIL-STD-2080A (AS), Maintenance Engineering Planning and Analysis for Aeronautical Systems, Subsystems, Equipment, and Support Equipment, since this standard is in the process of being canceled.

Section 2, Reference Documents, and paragraph 4.3.6 should include a reference to MIL-STD-2165.

Paragraph 10.3 should be revised to insert the words "testability, diagnostics" after the word "maintainability,".

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 2

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: MIL-H-46855B

TITLE: HUMAN ENGINEERING REQUIREMENTS FOR MILITARY SYSTEMS, EQUIPMENT, AND FACILITIES

EXISTING: X PLANNED:

STANDARDIZATION AREA: HFAC

PREPARING ACTIVITY: ARMY AMSMI-EDS, REDSTONE ARSENAL, AL
KATHY BROOKS, 205-876-0663

DOCUMENT PURPOSE:

This specification establishes and defines the requirements for applying human engineering to the development and acquisition of military systems, equipment, and facilities.

TESTABILITY/DIAGNOSTIC IMPACT:

This standard provides the human engineering input to the Integrated Diagnostics process, thus it will have a significant input to the revised MIL-STD-2165.

GENERAL RECOMMENDATIONS:

Significant modifications to this document are required to facilitate its use. These recommendations follow.

- o At present, permission has been received to retain this document as a military specification. The purpose and content of the document is identical to that of other programmatic standards covered in this report, including the system engineering standard, MIL-STD-499. Utilization of this document in the form of a specification is difficult. Such things

as references to appropriate DIDs are not included in specifications. It is recommended that this document be reissued as a standard.

- The format for this specification uses an application matrix of text modification for implementing the requirements over the various weapon system acquisition phases. This format is not conducive to easy use. It is recommended that the format used by other programmatic standards be applied.

- The application matrix contains guidance on when each human engineering function/task should be performed in relation to the weapon system acquisition cycle. Many of the tasks appear to be "out of sync" with the requirements in other programmatic standards, such as MIL-STD-1388-1A and MIL-STD-499. An example is the requirement to perform workload analysis in the Concept Exploration Phase of weapon system acquisition.

- Although the specification does clearly recognize a need for an allocation of functions between human, machine, and software, the required allocation described is not based on a mission-driven analysis.

- MIL-STD-2165 should be revised to reference inputs from MIL-H-46855 in relation to human engineering.

SPECIFIC MODIFICATIONS:

Revise paragraph 3.2.1, as follows:

"3.2.1 Analysis. Mission analyses shall be conducted to include: (1) a review of man/machine problems on similar systems and (2) a translation of mission requirements into system functions and subfunctions. The analyses shall include application of human engineering techniques as follows:

(a) Previous Man/Machine Problems. The operational and maintenance histories of previous, similar systems shall be reviewed to identify man/machine

problems to be avoided in the system under development. Types of problems to look for concern human responsibilities, manning, procedures, documentation, skill levels, and training.

(b) Mission and Function Analyses. The contractor shall identify and describe system functions/subfunctions without regard to the means of implementation (e. g., without describing whether man, machine/software, or some combination will perform the functions). The basis for identifying and describing these functions shall be the results of the analysis of 3.2.1.1 and a review of mission data (e. g., system operational requirements, modes of operation, usage, and support, mission objectives, and operating environments).

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 2

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: DOD-STD-2167

TITLE: DEFENSE SYSTEM SOFTWARE DEVELOPMENT

EXISTING: X PLANNED:

STANDARDIZATION AREA: MCCR

PREPARING ACTIVITY: SPAWAR, WASHINGTON, D. C. 202-692-3535

DOCUMENT *PURPOSE*:

This standard establishes requirements to be applied during the development and acquisition of mission-critical computer system (MCCS) software, as defined in DoD Directive 5000.29. This standard may also be applied to non-MCCS software development and acquisition.

TESTABILITY/DIAGNOSTIC IMPACT:

The requirements for software development will impact the development of diagnostic software embedded in weapon systems, subsystems, and in off-line ATE.

GENERAL RECOMMENDATION:

This standard defined the process requirements for the development of computer software configuration items (CSCI) and computer software components (CSC). The performance requirements for CSCI and CSC are contained in various types of specifications, as delineated in correlating DIDs. For example, the system/segment specification is defined in DI-CMAN-80008. This same DID is called out in MIL-STD-490A.

The comments made for MIL-STD-490A DID changes also apply to MIL-STD-2167. Namely, the System/Subsystem Specification DID (DI-CMAN-80008) should be modified to include a paragraph called "Diagnostics".

SPECIFIC MODIFICATIONS:

No changes are recommended for the Software Requirements and Software Product Specifications.

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO. 2:

REQUIREMENT TITLE: DESCRIBING VARIOUS TESTABILITY/ DIAGNOSTIC TASKS WHICH MUST BE UNDERTAKEN DURING EACH PHASE OF WEAPON SYSTEM ACQUISITION

DOCUMENT NUMBER: MIL-STD-1379B

TITLE: CONTRACT TRAINING PROGRAMS

EXISTING: X PLANNED:

STANDARDIZATION AREA: 69GP

PREPARING ACTIVITY: NAVAIR, 51122, WASHINGTON, D. C.
CAROLYN PARKER, 305-646-5912 OR 5592
NAVAL TRAINING EQUIPMENT CENTER,
ORLANDO, FL

DOCUMENT PURPOSE:

This standard establishes the requirements for preparing, validating, verifying, conducting, and revising training programs, which are required to qualify military and civilian technicians, instructors, or other personnel to operate, program, maintain, repair, overhaul, and instruct on the system/equipment.

TESTABILITY/DIAGNOSTIC IMPACT:

The standard deals with all types of training, including maintenance training.

GENERAL RECOMMENDATIONS:

The standard should be revised to address on-the-job training in relation to electronic delivery devices (maintenance aids).

SPECIFICATIONS MODIFICATIONS:

Paragraph 5.1.3: After the word "tools", add ", maintenance aids.".

Replace paragraph 5.5.12 with the following paragraph:
"5.5.12 On-The-Job Training (OJT) Material. On-the-job training (OJT) material shall be prepared to be utilized by the using activity as its primary vehicle in providing an effective maintenance capability in support of the deployed system/equipment. This material can take the form of an on-the-job handbook or an electronic delivery device and can be used to enhance and freshen technician training and facilitate training of less experienced crew members. As such, the training material must be developed to address the needs of both experienced and inexperienced technicians. Modifications to this OJT maintenance training material shall be enhanced to take advantage of knowledge gained through operational experience or during presentations of training courses."

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.:	3
REQUIREMENT TITLE:	DESIGNING THE DIAGNOSTIC CAPABILITY
DOCUMENT NUMBER:	MIL-STD-454J
TITLE:	STANDARD GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT
EXISTING: X	PLANNED:
STANDARDIZATION AREA:	GDRQ
PREPARING ACTIVITY:	HQ, AFSC/PLEQ, ANDREWS AFB, WASHINGTON, D. C. CAPT. SYLVESTER, 301-981-2751 HQ, ASD/ENES, WRIGHT-PATTERSON AFB, OH ROGER FAUST, 513-255-6295

DOCUMENT PURPOSE:

The standard covers the common requirements to be used in military specifications for electronic equipment. Each requirement is intended to cover some discipline in the design of equipment, such as the procedure, a process, or the selection and application of parts and materials.

TESTABILITY/DIAGNOSTICS IMPACT:

Reliability, maintainability, and human engineering are requirements that are included in this standard. These disciplines do not adequately address testability and diagnostics. For these types of engineering disciplines, the data sheets stress that this standard does not establish requirements and must not be referenced in contractual documents. Thus these three requirement examples offer direction on what must be considered in preparing contractual documents.

GENERAL RECOMMENDATION:

It appears that the above three (3) requirement data sheets were included in this standard to alert users that there were requirements for reliability, maintainability, and human engineering. Since these requirements cannot be

referenced in contractual documents, their inclusion is somewhat superficial. In fact, the NSIA Integrated Diagnostics Group recommended that Integrated Diagnostics not be included in the standard. They felt that the standard was of benefit only to the specification preparer and not the user. In addition, they felt that a requirement for automatic test equipment not be included but, rather, addressed in MIL-STD-415.

SPECIFIC MODIFICATIONS:

Although it is somewhat superficial, it is recommended that the attached Requirement No. 76, which addresses Integrated Diagnostics, be included in this standard to alert users on how to address this type of process.

REQUIREMENT 76

INTEGRATED DIAGNOSTICS

1. Purpose: This requirement establishes a design process for integrating all elements which constitute a weapon system's diagnostic capability. IT DOES NOT ESTABLISH REQUIREMENTS, AND MUST NOT BE REFERENCED IN CONTRACTUAL DOCUMENTS. Engineering analyses, quantitative requirements, design analysis, and demonstration and maturation requirements must be specified in the contract or system/equipment specification, as appropriate.

2. Documents Applicable to Requirement 76:

MIL-STD-2165 -- Testability Program for Electronic Systems and Equipments

MIL-STD-471 -- Maintainability Verification/Demonstration/Evaluation

3. Integrated Diagnostics Process:

Integrated Diagnostics is defined as a structured process which maximizes the effectiveness of diagnostics by integrating pertinent elements, such as testability, automatic and manual testing, training, maintenance aiding, and technical information as a means for providing a cost-effective capability to detect and unambiguously isolate all faults known or expected to occur in weapon systems and equipment and to satisfy weapon system mission requirements.

This emphasis on the design and acquisition of the diagnostic capability is required because this capability transcends a multitude of other design disciplines (e. g., reliability, maintainability, logistics support, human engineering), and thus the capability tends to become fractionated. The major implementing document is MIL-STD-2165. However, because it is a multidisciplined process, reference will probably be required to portions of other military standards and specifications (e. g., MIL-STD-785, MIL-STD-1388-1, MIL-STD-470, MIL-STD-499, and MIL-H-46855).

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.:	3
REQUIREMENT TITLE:	DESIGNING THE DIAGNOSTIC CAPABILITY
DOCUMENT NUMBER:	MIL-STD-415D
TITLE:	DESIGN CRITERIA FOR TEST PROVISIONS FOR ELECTRONIC SYSTEMS AND ASSOCIATED EQUIPMENT
EXISTING: X	PLANNED:
STANDARDIZATION AREA:	MISCELLANEOUS
PREPARING ACTIVITY:	ASD/ENES, WRIGHT-PATTERSON AFB, DAYTON OH MARY COURY, 513-255-6295

DOCUMENT PURPOSE:

This standard establishes design criteria for test provisions that permit the functional and static parameters of electronic systems and associated equipment to be monitored, evaluated, or isolated.

TESTABILITY/DIAGNOSTIC IMPACT:

The last revision to this standard was in October 1971, and thus the design criteria is outdated and needs to be rewritten.

GENERAL RECOMMENDATIONS:

The standard addresses older technologies, such as external test receptacles for connecting prime equipment to automatic monitoring equipment. A complete rewrite of the standard is required to address new technologies, system architectures, and the prime system's entire diagnostic capability.

SPECIFIC RECOMMENDATIONS:

The following is an outline of the content and thrust of the new standard.

TITLE -- Design Criteria for Diagnostic Provisions for Systems and Equipments

SECTION 1 -- SCOPE

The scope and purpose of the standard should be expanded to address design criteria for the entire prime system's diagnostic capability.

SECTION 3 -- DEFINITIONS

Some of the definitions are obsolete, such as automatic monitoring equipment. The entire list of definitions should be screened and appropriate MIL-STD-721 and MIL-STD-1309 definitions incorporated.

SECTION 4 -- GENERAL REQUIREMENTS

The entire section on general requirements is aimed at the analysis to determine test provisions that are required for operation and maintenance. This type of information is presently required by a number of programmatic standards, foremost of which is MIL-STD-2165 (both the present MIL-STD-2165 and the proposed revised standard). Reference should be made to these standards, while alerting the designer that he must take into consideration the various diagnostic elements which must be considered (e. g., performance monitoring, fault-tolerant systems, electronic delivery of technical information, and on-the-job training aids). In addition, the designer should be reminded that this covers the entire weapon system, including diagnostics for mechanical and structural items.

SECTION 5 -- DETAIL REQUIREMENTS

Paragraph 5.2.1, General Design Considerations, should be expanded to include the following subjects:

- o The concept of vertical testability--from factory to field

- The requirement for a cohesive diagnostic design process to address diagnostic and test program development/generation, treated as a single design process applicable to all levels of maintenance (e. g., interfaces among MIL-STDs 756, 1629, 1519, 1345, 2077)

- Support strategies for VLSI/VHSIC

- Failure reporting and logging of field performance of the weapon system's diagnostic capability, treated as a single entity, addressing all level of maintenance.

Paragraph 5.2.2, Automatic Checkout and Automatic Monitoring Capabilities, needs to be completely rewritten to address off-line ATE in lieu of on-line ATE. Some of the design criteria which should be addressed include:

- The utilization of IEEE ATLAS 716 as the test language

- Control of the interface between the UUT and the ATE, including criteria covering the design of the interface device

- Guidance on the appropriate use of general-purpose ATE, as opposed to special purpose.

Paragraph 5.2.3 deals with BIT capability. This paragraph needs to be expanded to cover such design criteria for:

- Performance monitoring/status monitoring/in-flight monitoring and recording, including performance degradation

- Performance monitoring in relation to fault-tolerant design

- Performance monitoring for mechanical and structural items, including sensor design criteria and time-stress measurement devices

- Test measurement bus structure

- Smart BIT (expert systems technology)

- Delete the requirement for the interpretation of BIT output by low-skilled personnel

- Reference should be made to the Joint Service Built-In Test Design Guide and the NBS Sensor Handbook for Test, Monitoring, Diagnostic, and Control System Applications to Military Vehicles and Machinery.

- Review contents of Task 104, MIL-STD-2084 (AS) for possible inclusion, since this standard establishes criteria for the design and application of BIT.

Paragraph 5.2.4, Test Points, should be revised to address design criteria for test point selection. The criteria delineated in Section 6 of MIL-STD-1326 (Navy) should be considered for this expansion, including the use of paragraph 3.0 in the appendix to this standard, as an example of optimum test point selection. The design criteria contained in MIL-STD-2084 (AS), Task 105, should also be reviewed for inclusion.

Add a new paragraph: "5.2.5 Electronic Delivery of Technical Information." This paragraph should address the following design criteria.

- Types of information (e. g., procedural, historical, systematic)

- Maintenance aiding, including the application of expert system technology

- Training aids, embedded in the prime system and external to the prime system, utilized for on-the-job training

- Compatibility of technical information used for both maintenance aiding and training

- Application of standards addressing the authoring of technical information (e. g., LISP) and interchange of technical information (e. g., CALS standards, test buses, BIT)

- The interface with common data bases.

- The configuration management of expert system software, which may differ from weapon system to weapon system of the same type.

Paragraph 5.3, Human Engineering Requirements, should be expanded to address design criteria and standards utilized in transferring technical information from the machine (e. g., ATE, maintenance aids, training aids) to the technician. This includes addressing comprehensibility, formats, ready access to information, etc.

Section 6 needs revision to modify the ordering data and data preparation instructions to conform to the additional requirements contained in Section 5.

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.:	3
REQUIREMENT TITLE:	DESIGNING THE DIAGNOSTIC CAPABILITY
DOCUMENT NUMBER:	MIL-STD-1345B (NAVY)/MIL-STD-1519 (USAF)/MIL-STD-1519 (UPDATE) (MATE)
TITLE:	PREPARATION OF TEST REQUIREMENTS DOCUMENT
EXISTING: X	PLANNED:
STANDARDIZATION AREA:	MISC
PREPARING ACTIVITY:	NAVSEA 55Z3, WASHINGTON, D. C. JEAN HARMON, 202-692-0160 ASD/ENES, WRIGHT-PATTERSON AFB, DAYTON, OH MARY COURY, 513-255-6295

DOCUMENT PURPOSE:

To establish the requirements for the preparation and control/acceptance of the Test Requirements Document (TRD) used in specifying testing requirements for electronic system/subsystems, units, assemblies/subassemblies referred to as units under test (UUTs).

TESTABILITY/DIAGNOSTIC IMPACT:

The TRD provides the UUT data needed to specify and design the off-line diagnostics (i. e., ATE/TPS FD/FI levels).

GENERAL RECOMMENDATIONS:

Three MIL-STDs currently delineate requirements for a TRD: MIL-STDs 1345 (Navy), 1519 (USAF), and 1519 (Updated/MATE). It is recommended that the three documents be combined into one standard, incorporating the elements of all three, as shown in the specific modifications below.

SPECIFIC MODIFICATIONS:

The above three standards all have the same title, "Test Requirements Document, Preparation of." The amount of detail required in each TRD increases by placing the standards in the following order.

MIL-STD-1519 requires the minimum, MIL-STD-1345B increases MIL-STD-1519, and MIL-STD-1519 (Updated) increases the requirements of MIL-STD-1345B. A comparison of TRD requirements that impact testability/diagnostics is shown below.

TRD REQUIREMENT	MIL-STD-1519	MIL-STD-1345B	MIL-STD-1519 (UPDATED)
1. ATPG Requirements	Not addressed	Stated	Not addressed
2. ATLAS Requirements	Not addressed	Stated	Stated
3. Testing of Built-In Test (BIT)	Not addressed	Stated	Stated
4. Testability Analysis Report	Not addressed	Not addressed	Stated
5. Interface to Prime System Life Cycle	Not addressed	Not addressed	Defined
6. CAD/CAE Data Reqmts.	Not addressed	Not addressed	Not addressed
7. Failure Rate and Fault Isolation Ambiguity Group Summary	Not addressed	Tables provided	Table provided

MIL-STD-1519 (Updated) is included in MATE Guide 5, Volume 3, Part 6 data. It was prepared using both MIL-STD-1519 and MIL-STD-1345 as references.

From the above analysis, it can be seen that MIL-STD-1519 does not address ATPG data and does not contain requirements for CAD/CAE data. MIL-STD-1519 (Updated) has been formatted to provide Part A, Minimum Essential Data Requirements, at the completion of the UUT PDR, Part 3; Developmental Test Requirements and Testability Data Analysis, at the completion of the UUT CDR; and Part C, Production Base Line Data, at the completion of the UUT FCA and again at the completion of the UUT PCA.

It is recommended that MIL-STD-1519 (Updated) be revised to include ATPG and CAD/CAE data requirements and, after the revision is completed, be identified as the sole test requirements document standard by canceling MIL-STD-1519 and MIL-STD-1345B.

Recommended CAD/CAE data requirements that should be included in the TRD Standard:

"X.X.1 CAD/CAE Data Requirements. Contractors who design UUT with CAD/CAM systems shall provide the following data:

a. Identification of the CAD/CAE system used

b. Description of test strategy included as part of the UUT design

c. Failure modes, effects, and criticality analysis

d. Predicted fault detection and fault isolation levels

e. Media on which test vectors are stored

f. Identification of UUT built-in test

g. Descriptions of UUT interface characteristics

h. Copies of all the original "source listings" of any test sequence

i. Data postprocessing requirements.

X.X.2 Automatic Test Program Generation (ATPG) System Information.

Incorporate paragraph 5.5.3 of MIL-STD-1345B into the revised MIL-STD-1519 (Updated)."

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 3

REQUIREMENT TITLE: DESIGNING THE DIAGNOSTIC CAPABILITY

DOCUMENT NUMBER: MIL-STD-2077 (NAVY)

TITLE: GENERAL REQUIREMENTS FOR TEST PROGRAM SETS

EXISTING: X PLANNED:

STANDARDIZATION AREA: MISCELLANEOUS

PREPARING ACTIVITY: NAVAIR, 51122, WASHINGTON, D C.
WALTER CORNETZ, NAEC, 201-323-7489

DOCUMENT PURPOSE:

This document establishes a standard for design, development, documentation, configuration management, validation, verification, quality assurance and preparation for delivery of Test Program Sets (TPS).

TESTABILITY/DIAGNOSTICS IMPACT:

The requirements for TPS development stated in this standard provide a method for developing TPSs that meet specified off-equipment diagnostic capability parametric values of fault detection/fault isolation.

GENERAL RECOMMENDATIONS:

This standard has been developed for the Naval Air Systems Command, the Space and Naval Warfare Systems Command, and the Naval Sea Systems Command. It uses terms and states requirements that are peculiar to Navy utilization of TPSs. The Foreword of the standard requires that careful attention to tailoring of the requirements be accomplished to avoid duplication of data and to ensure that TPSs provide useful information to serve their intended function.

It is recommended that a "tailoring" section be included in the standard to serve as guidance to selectively apply and tailor the MIL-STD requirements for Air Force and Army applications.

SPECIFIC MODIFICATIONS:

Add the following sentence to the Foreword on page iii: "Specific tailoring guidance for Army and Air Force users of the standard is provided in Appendix D."

Page 12, paragraph 5.1.7.9: Change second sentence to read: "All test programs shall be designed to provide maximum percent fault detection consistent with UUT testability, ATE design, and reasonable cost targets; minimum fault detection shall be specified as a percentage of total detectable faults."

Add Appendix D, as follows:

"APPENDIX D

APPLICATION GUIDE FOR TAILORING MIL-STD-2077(A)

10 SCOPE

10.1 General. This appendix sets forth guidance for the application of this standard for Air Force and Army requirements.

10.2 Purpose. The guidelines contained herein selectively provide for the conversion of Navy-peculiar TPS requirements to Air Force and Army applications.

20 CONSIDERATIONS FOR TAILORING

20.1 Air Force. The Air Force has developed and institutionalized the MATE System. The MATE System contains detailed guidance, tools, and models developed specifically for TPS specification, design, and support. The procuring activity shall use the MATE System TPS products for guidance in the generation of a TPS SOW and specification that conforms to the requirements of this standard and the MATE System.

20.2 Army. The Army Materiel Command, through the Product Manager--TPS, has developed and distributed an AMC TPS Procedures Manual. This TPS Procedures Manual provides the guidance and tools necessary for the acquisition, design, and support of Army TPSs. Army Program Managers shall use the AMC TPS Procedures Manual for guidance in the generation of Army TPS SOWs and specifications. "

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 3

REQUIREMENT TITLE: DESIGNING THE DIAGNOSTIC CAPABILITY

DOCUMENT NUMBER:

TITLE: JOINT SERVICE BUILT-IN TEST DESIGN GUIDE

EXISTING: X PLANNED:

STANDARDIZATION AREA: ATTS

PREPARING ACTIVITY: NAVSEA, WASHINGTON, D. C.
PAUL GROSS, 202-692-2035

DOCUMENT PURPOSE:

The Joint Service Built-In Test (BIT) Design Guide provides detailed guidelines on the implementation of BIT. It provides information on development of BIT strategies, BIT tradeoffs, and BIT design techniques. It is a guidance document only and contains no requirements.

TESTABILITY/DIAGNOSTICS IMPACT:

BIT is a key diagnostic element. Proper design and implementation of BIT is crucial to an effective diagnostics capability. Therefore, guidance on BIT design is very important and the BIT Design Guide serves an important function in diagnostics implementation.

GENERAL RECOMMENDATIONS:

Although the BIT Design Guide is over six years old, it contains very useful and relevant information on BIT design. It was recently updated, with a section on component BIT. The guide should be updated to include additional BIT topics to assure that all aspects of BIT are addressed. Much of the useful information in the guide is contained within sections which are oriented toward specific examples of BIT implementation. Unless the user reads the guide cover-to-cover, he is not likely to find certain key guidelines. Therefore, an index of the information in the guide would be extremely useful.

SPECIFIC MODIFICATIONS:

The BIT Design Guide is the only guide oriented toward BIT. Several other very good design guides exist and are readily available, such as the MATE Avionics Testability Design Guide and the RADC Testability Notebook. These should be referenced in the BIT Design Guide, so that a user needing additional information can be informed where and how to find it.

The information contained in the BIT Design Guide is excellent, but not totally complete. The BIT Design Guide should be expanded to include sections on BIT Prognostics, BIT Software, and Analog BIT. The BIT Requirements Analysis section should be expanded and given an integrated diagnostics flavor. The BIT approaches section should be updated to include test and maintenance bus techniques at the system level and integration aspects of BIT. A section should be added on BIT Evaluation.

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 3

REQUIREMENT TITLE: DESIGNING THE DIAGNOSTIC CAPABILITY

DOCUMENT NUMBER: MIL-HDBK-338

TITLE: ELECTRONIC RELIABILITY DESIGN HANDBOOK VOLS. 1 AND 2

STANDARDIZATION AREA: RELIABILITY

PREPARING ACTIVITY: RADC, ROME, NY
CHARLES MESSENGER, 315-330-3766

DOCUMENT PURPOSE:

This handbook is an update and extensive revision of the Reliability Design Handbook, published in 1976 by the Reliability Analysis Center under contract to RADC. The handbook contains pertinent and practical guidelines for use by design engineers, reliability engineers, and managers to design, produce, and deploy reliable and maintainable military electronic equipment/systems at minimum life cycle cost.

TESTABILITY/DIAGNOSTIC IMPACT:

Although the title of the document implies a strict reliability focus, the handbook describes a comprehensive methodology covering many aspects of electronic system design engineering and cost analysis as they relate to the design acquisition, and deployment of DoD equipment/systems. The sections on Failure Modeling (5.2.3), Reliability Prediction Techniques (6.4), Transient and Overstress Protection (7.4.4), Parameter Degradation and Analysis (7.4.5), Redundancy (7.5), Failure Modes and Effects Analysis (7.8), Fault Tree Analysis (7.9), and Software Reliability (9.0) are strongly linked to testability and diagnostics.

GENERAL RECOMMENDATIONS:

The sections described above should be expanded to accommodate current state-of-the-art (S.O.A.) techniques and theory applicable to these diagnostics-related technology areas.

SPECIFIC MODIFICATIONS:

Section 5.2.3 (Failure Modeling) is essential to the diagnostic design process, but its treatment in MIL-HDBK-338 addresses mathematical (i. e., failure rate), as opposed to the actual physical models of both "good" and "bad" devices. Although validated failure rate models are essential to the development of reliability prediction techniques, this approach provides a level of abstraction far removed from reality. From a diagnostics point of view, the reliability discipline, in conjunction with the electrical engineering discipline, must provide generic model representations of fault-free devices (i. e., VHDL, gate level, circuit level, etc.). "Faulty" device models also need to be developed, which emulate, from an electrical point of view, known device failure modes. This section of the handbook must come to grips with, and address, this difficult, but important, concept of physical fault modeling in order for the handbook to have applicability to broader diagnostic arenas.

Section 6.4 (Reliability Prediction Techniques) should be augmented to encompass how the reliability discipline can be utilized to predict test effectiveness as part of the weapon system design process. In particular, the utilization of reliability-based data to predict testability-related Figures of Merit, such as Fraction of Faults Detected (FFD), Fraction of False Alarms (FFA), Fraction of False Status Indications (FFSI), Test Thoroughness (TT), and Fraction of Faults Isolated (FFI) should be discussed in a new section, titled: "Mathematical Models for Testability Prediction."

Section 7.4.4 (Transient and Overstress Protection) should be expanded to include transmission systems--both electrical/electronic (i. e., cable, bus systems) and fiber optics. Computerized transient analysis modeling/prediction techniques should also be addressed.

Section 7.4.5 (Parameter Degradation and Analysis) should be modified and expanded to provide more in-depth criteria and methodology on how to perform nominal, worst case, Monte Carlo, and parameter variation analysis. These techniques should be demonstrated utilizing computer-aided design tools, such as SPICE. The result of the methodology should be a design and analysis approach which enables the designer to derive technically sound performance limits for the subject unit under test. Utilizing these performance limits, the derivation of reliable test limits, utilizing

UUT performance limits and ATE/BIT stimulus/measurement/switching performance uncertainties should be demonstrated.

This approach will enable designers, in essence, to design more reliable equipment, by virtue of designing for realistic testing tolerance across all levels of equipment indenture (i. e., Factory, Depot, Intermediate, Organizational Levels) and eliminating/minimizing the Retest Okay (RTOK) problem.

The sections on redundancy, in paragraph 7.5 (Redundancy) and as amplified in Appendix A (Redundancy Considerations in Design), are excellent. From a diagnostic viewpoint, these sections should be updated and expanded to provide more detailed examples of various modern BIT techniques, utilized in concert with redundancy, and their resulting impact on overall system reliability. In addition, Section 7.5 (Redundancy) should be expanded to address reliable design techniques to fault detect and transmit data pertaining to faults occurring in systems employing redundancy techniques. The issue here is that, unless one knows whether a fault has indeed occurred, one cannot predict the reliability of a device at a particular instant in time. The upcoming Tri-Service Testability Analysis Handbook and BIT Design Guide should be utilized as input to this update.

Section 7.8 (Failure Modes and Effects Analysis) should be augmented to provide an in-depth and up-to-date discussion of computer-assisted failure mode and effects analysis. The present discussion in the handbook (paragraph 7.8.5, Computer analysis) is both terse and obsolete. Modern circuit analysis programs (i. e., analog and digital) and fault models currently available to simulate failures in electronic circuits and to automatically ascertain their effects should be discussed in detail in this section, along with appropriate examples, to demonstrate the key concepts presented.

The utilization of FMEA techniques to analyze "soft fault" conditions currently being experienced in modern-day weapon systems should also be discussed in depth.

Section 7.9 (Fault Tree Analysis) should be rewritten, utilizing modern-day logic modeling techniques (i. e., dependency modeling) to demonstrate how a failure mode at one level of equipment indenture can produce a failure at a higher level in the system. Utilization of modern, cur-

rently available computerized tools, such as LOGMOD or the Navy's Weapon System Testability Analyzer (WSTA), should be applied within this section to demonstrate the concept of automated fault tree analysis.

Section 9.0 (Software Reliability) should be augmented to address modern-day thinking with respect to software validation/verification techniques. Specifically, Section 9.8.4 (Program Checking and Testing) should be expanded to incorporate new debugging and integration testing techniques to ensure fault-free software systems.

In summary, this document would serve as an excellent vehicle for addressing the specific design aspects of design for testability/diagnostics as it relates to reliability and maintainability. It is probably one of the better, if not the best, design handbooks available within DoD.

DOCUMENT ANALYSIS SHEET

REQUIREMENT NO.: 3

REQUIREMENT TITLE: DESIGNING THE DIAGNOSTIC CAPABILITY

DOCUMENT NUMBER:

TITLE: SENSOR HANDBOOK FOR TEST, MONITORING, DIAGNOSTIC AND CONTROL SYSTEM APPLICATIONS TO MILITARY VEHICLES AND MACHINERY

EXISTING: X PLANNED:

STANDARDIZATION AREA: ATTS

PREPARING ACTIVITY: NBS, WASHINGTON, D. C.

DOCUMENT PURPOSE:

The Sensor Handbook is intended as a guide for those who design, specify, use, and test military automatic test equipment containing sensors. The handbook addresses measurands and principles of measurement, data acquisition, sensor calibration and testing, environmental considerations, stability, durability, reliability, and error assessment. The handbook is addressed to the general engineer, system designer, or manager with an engineering background. It does not provide the highly detailed technical information needed by a design engineer, although ample references are included for further study.

TECHNOLOGY/DIAGNOSTIC IMPACT:

The primary application of the handbook is for BIT applications which require various sensor technologies to detect/measure various parameters such as pressure, motion, flow, temperature, force and torque, level, humidity moisture, etc., which are being experienced by a weapon system or elements of a weapon system.

GENERAL RECOMMENDATIONS:

There should be a modification and update of the handbook to reflect sensor technologies and design techniques to enable the design of "Smart BIT" by a weapon system designer.

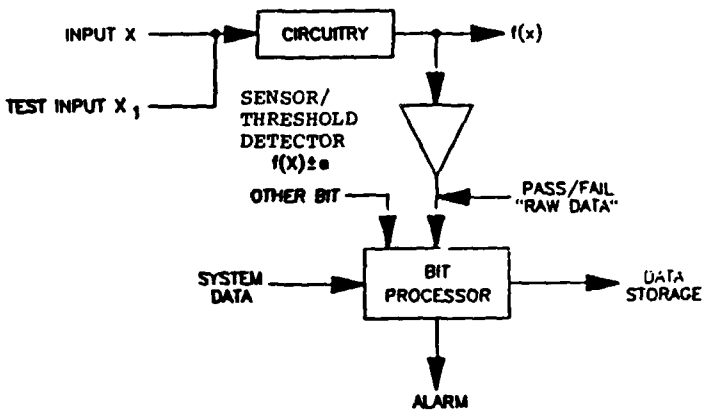
SPECIFIC MODIFICATIONS:

Based upon BIT experience to date on major programs (i. e., B-1B, F-16, F-18, etc.), identify sensor requirements for "Smart BIT." Develop a generic "Smart BIT" sensor detection, data acquisition, and data analysis scheme which can be tailored to specific weapon systems. In particular, focus on the primary culprits of BIT false alarms, such as electrical transients and vibration in the development of this "Smart BIT" architectural design. Emphasis should be placed on the specification and utilization of generic sensors by design engineers in the context of a generalized diagnostic data acquisition and data analysis system. Generic software schemes to sample, filter, log, and analyze BIT sensor data should also be provided. An outline of the proposed addition to the handbook is provided below:

"SENSOR APPLICATIONS FOR SMART BIT

1.0 INTRODUCTION
  1.1 Need for Smart BIT (False Alarm Problem)
  1.2 Sensor Role in Smart BIT

2.0 SMART BIT MODEL
  2.1 Model Overview



2.2 Function of Threshold Detector

2.3 Determining Pass/Fail Limits

2.4 BIT Processor
- 2.4.1 System Data Requirements
- 2.4.2 Data Storage Requirements
- 2.4.3 Criteria for Alarm Generation

3.0 SMART BIT SENSOR REQUIREMENTS

3.1 Minimum, But Essential, Sensor Technology Requirements
- 3.1.1 Vibration/Shock
- 3.1.2 Noise
- 3.1.3 Transients
- 3.1.4 Voltage/Current Sensing
- 3.1.5 Temperature/Humidity Sensing
- 3.1.6 Angular Displacement
- 3.1.7 Pressure Displacement
- 3.1.8 Motion
- 3.1.9 Force/Torque

3.2 Sensor Operational Attributes
- 3.2.1 Calibration
- 3.2.2 Fault tolerance/Redundancy

3.3 Sensor Application Attributes
- 3.3.1 Packaging (Hardware)
- 3.3.2 Programmability (Adaptable Software)

4.0 SMART BIT SYSTEM ARCHITECTURE UTILIZING SENSOR TECHNOLOGY

4.1 Generic (Adaptable) System Architecture
4.2 Sensor Interface Requirements
4.3 Data Acquisition Requirements
4.4 Operational Software Requirements
- 4.4.1 Minimizing False Alarms While Maintaining Safety
- 4.4.2 Filtering Out Non-Solid Failures
  - 4.4.2.1 Retry Failing Operation "n" times
  - 4.4.2.2 Declare Solid Failure Only if "n" No-Gos
  - 4.4.2.3 Replacement of Corrupted Data
- 4.4.3 Log Intermittent Failures/Sensor Data

4.4.4 Improve Probability of Sensor Fault Detection
- 4.4.4.1 Cycle Instructions
- 4.4.4.2 Cycle Programs
- 4.4.4.3 Cycle BIT and Acquire Sensor Data Under Different System Operational Scenarios
- 4.4.4.4 Log "Soft" Failure History/Sensor Data
- 4.4.4.5 Determining the Need for "Adaptive" Test Limits

4.5 Criteria and Application Guidelines for Applying Sensor to Smart BIT Applications"

In addition, the handbook should be coordinated and issued as a military handbook.

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 4

REQUIREMENT TITLE: CONDUCTING DESIGN REVIEWS

DOCUMENT NUMBER: MIL-STD-1521B (USAF)

TITLE: TECHNICAL REVIEWS AND AUDITS FOR SYSTEMS, EQUIPMENT, AND COMPUTER PROGRAMS

EXISTING: X PLANNED:

STANDARDIZATION AREA: MISC.

PREPARING ESD/PLEA, BEDFORD, MA
RICH O'NEILL, 617-377-2703
HQ AFSC/SDX, ANDREWS AFB, WASHINGTON, D. C.
MAJ. MILLER, 301-981-3316

DOCUMENT PURPOSE:

This standard prescribes the requirements for the conduct of technical reviews and audits on systems, equipments, and computer software.

TESTABILITY/DIAGNOSTIC IMPACT:

The appendices in MIL-STD-1521B provide the guidance for the conduct of the identified technical reviews and audits in the form of checklists. These checklists contain the purpose of the particular technical review/audit and a list of items to be reviewed. The items to be reviewed conform to the system engineering process and are basically generic. The design of the diagnostic capability is reviewed and evaluated through the conduct of technical reviews and audits, in accordance with the requirements of the standard.

GENERAL RECOMMENDATIONS:

Several of the appendices in the standard should contain additional diagnostic capability-related review items to ensure that the diagnostic capability is properly evaluated and measured. Collation of several diagnostic capability review items should be accomplished in several appendices in order to provide more clarity and effectiveness in the diagnostic capability review process.

SPECIFIC MODIFICATIONS:

The following additions/changes to the identified review/audit are recommended.

Appendix A -- Systems Requirements Review (SRR)

Page 19, paragraph 10.3h, 2nd line: Between the words "analysis," and "armament", insert "diagnostic capability analysis,".

Appendix B -- System Design Review (SDR)

Page 24, paragraph 20.2.3d, 3rd line: Between the words "analysis," and "maintainability", insert "diagnostic capability analysis,".

Page 25, paragraph 20.3.1: After subparagraph "g.", insert a new subparagraph "h. Diagnostic Capability" and reletter each subsequent subparagraph alphabetically, beginning with the letter "i.".

Page 26, paragraph 20.3.2h: Change the first word, "Testability" to "Diagnostic Capability".

Page 28, paragraph 20.3.11: After subparagraph "a.", insert a new subparagraph "b. Diagnostic capability requirements in the updated system/segment specification". Reletter the subsequent subparagraphs alphabetically, beginning with the letter "c.".

Appendix D -- Preliminary Design Review (PDR)

Page 34, paragraph 40.2.1m: Between "availability" and "data", insert "/diagnostics capability".

Page 37, paragraph 40.2.3: After subparagraph "f.", insert a new subparagraph, "g. Review support equipment diagnostic capability" and reletter subsequent subparagraphs alphabetically, beginning with the letter "h.".

Page 38, paragraph 40.2.3.1, 2nd sentence: Change the sentence to read, "Relate this to the development of Built-In Test (BIT)/Built-In Test Equipment (BITE), Testability attributes, and try to reduce the need for complex support equipment."

Page 40, subparagraph 40.6.7: Delete paragraph 40.6.7.

Page 42: Insert a new paragraph 40.8, as follows:

"40.8 Diagnostic Capability

40.8.1 Identify the quantitative diagnostic capability requirements specified in the hardware development and software requirements specifications; if applicable, compare preliminary predictions with specified requirements.

40.8.2 Review the results of the analysis of the inherent (intrinsic) testability of the preliminary design.

40.8.3 Identify the BIT/BITE, status monitoring, fault/detection, fault/isolation levels; if applicable, compare preliminary predictions with specified requirements.

40.8.4 Review the sensitivity of diagnostic capability quantification parameters (FD/FI levels) on:

a. Maintainability (MTTR)

b. Reliability (MTBF)

c. Manpower and Personnel Requirements

d. Training Requirements

e. Technical Information Requirements

f. Off-Equipment Testing Requirements."

Renumber existing paragraph "40.8 System Safety" to "40.9," and add one digit to each subsequent existing paragraph (e. g., 40.10 to 40.11,etc.).

Page 48, paragraph 40.14.2: After the first sentence add the following in parentheses, "(including diagnostic capability-related data items.)"

Appendix E -- Critical Design Review (CDR)

Page 54, paragraph 50.2.1c: Between current listings "(8) and (9)," add a new listing: "(9) Diagnostic Capability". Renumber each subsequent listings by increasing it by one (e. g., existing 9 to 10, etc.).

Page 61: Insert new paragraph, as follows:

"50.8 Diagnostic Capability

50.8.1 Review the most recent predictions of diagnostic capability quantitative values and compare these against requirements specified in the *HWCI Development Specification and Software Requirements Specification.*

50.8.2 Review compatibility of HWCI and CSCI diagnostic capability quantitative values with external diagnostic capability detail specifications.

50.8.3 Identify unique diagnostic capability procedures required for the configuration item during operational use and evaluate their total effect on system maintenance concepts and support requirements.

50.8.4 Review detailed maintainability demonstration plan for inclusion of diagnostic capability test requirements."

Renumber existing paragraph, "50.8 System Safety" to "50.9", and renumber each subsequent paragraph in numerical order (e. g., existing 50.9 to 50.10, etc.).

Page 64, paragraph 50.14.3: On second line, insert "Diagnostic Capability" between "Maintainability" and "Data".

DOCUMENT IMPROVEMENT REPORT

REQUIREMENT NO.: 6

REQUIREMENT TITLE: ASSURING THE DELIVERY OF AN ADEQUATE DIAGNOSTIC CAPABILITY

DOCUMENT NUMBER: MIL-STD-471A

TITLE: MAINTAINABILITY VERIFICATION/DEMONSTRATION/EVALUATION

EXISTING: X PLANNED:

STANDARDIZATION AREA: MISCELLANEOUS

PREPARING ACTIVITY: RADC/RBE-2, ROME, NY
JOSEPH CAROLI, 315-330-4205

DOCUMENT PURPOSE:

MIL-STD-471A provides procedures and test methods for verification, demonstration, and evaluation of qualitative and quantitative maintainability requirements. It also provides for qualitative assessment of various integrated logistic support factors related to and impacting the achievement of maintainability parameters and item downtime, e. g., technical manuals, personnel, tools and test equipment, maintenance concepts and provisioning.

TESTABILITY/DIAGNOSTIC IMPACT:

M I L - S T D - 4 7 1 A , M a i n t a i n a b i l i t y Verification/Demonstration/Evaluation is the logical requirements document. This establishes provisions for testability and diagnostics demonstration related to fault detection and fault isolation capability provided by the integrated diagnostics elements, including built-in test, test equipment, technical manuals, and skills.

GENERAL RECOMMENDATIONS:

MIL-STD-471A currently addresses demonstration of "maintainability tasks and procedures," which by definition includes diagnostics procedures. However, emphasis is not

given to diagnostics (fault detection and fault isolation) parameters. It is recommended that diagnostics procedures to be demonstrated be emphasized within MIL-STD-471 and that formal linkages to MIL-STD-2165 be provided.

SPECIFIC MODIFICATIONS:

Paragraph 1.1:

Change "maintainability requirements" to maintainability and diagnostics requirements".

Change "maintainability parameters" to "maintainability and diagnostics parameters".

Change last line to: "e. g., built-in test, technical manuals and maintenance aids, personnel and skill levels, tools and test equipment, maintenance concepts and provisioning."

Section 2:

Include MIL-STD-2165 as a reference.

Include MIL-STD-721C as a reference.

Section 3:

Include Testability and Diagnostics definitions.

Section 4:

Add at end of paragraph 4.1:

"j. A testability demonstration shall be performed in conjunction with the maintainability demonstration and in accordance with the maintainability test plan.

The testability demonstration is designed to:

1. Ascertain if operational system checks can detect the presence of failures, per the development specification.

2. Ascertain if system/equipment/module BIT can detect and isolate failures, per the development specification.

3. Ascertain if each UUT is compatible with the ATE(s).

It shall be performed in accordance with the requirements of 8 December 1978 addenda to this standard titled "Maintainability Verification/Demonstration/ Evaluation."

Appendix B Modifications:

- A family of curves for various confidence levels is required.
- The procedures identify a symbol that represents sample size. Nowhere in the procedure is the sample size defined. This is required in order to use the procedure.
- A sequential analysis technique must be included or the insertion of multiple faults must be addressed.
- Provide formulae to compute false alarm rate acceptance/rejection criteria, based on confidence levels."

DOCUMENT IMPROVEMENT SHEET

REQUIREMENT NO.:	8
REQUIREMENT TITLE:	STANDARDIZATION OF DEFINITIONS
DOCUMENT NUMBER:	(1) MIL-STD-721C
TITLE:	DEFINITIONS OF TERMS FOR RELIABILITY AND MAINTAINABILITY
DOCUMENT NUMBER:	(2) MIL-STD-1309C
TITLE:	DEFINITION OF TERMS FOR TEST, MEASUREMENT, AND DIAGNOSTIC EQUIPMENT
EXISTING: X	PLANNED:
STANDARDIZATION AREA:	(1) RELIABILITY (2) ATTS
PREPARING ACTIVITY:	(1) NAVAIR, 51122, WASHINGTON, D. C. JOHN COOK, 201-323-7458, NAEC (2) NAVSEA 55Z3, WASHINGTON, D. C. JEAN HARMON, 202-692-0160

DOCUMENT PURPOSE:

There are two standards which are dedicated to defining diagnostic and testability terms.

The first is MIL-STD-721C, Definition of Terms for Reliability and Maintainability. This document is dated 12 June 1981. It defines words and terms most commonly used, which are associated with reliability and maintainability. It is under the reliability standardization area, and NAVAIR is the preparing activity. It contains a definition of 128 terms, many of which are inherently testability and diagnostic terms. However, the terms "diagnostics" and "testability" are not included. This standard more closely fits the definition of a standard because most of the terms used are mutually exclusive of one another.

The second standard is MIL-STD-1309C, which was issued 18 November 1983. The title of this standard is "Definition of Terms for Test, Measurement, and Diagnostic Equipment." The definitions that are included in this standard are ex-

tracted from a number of other standards, handbooks, specifications, and other documents. Although the standard relates to TMDE, many of the terms do not have a direct relationship to TMDE (e. g., testability, reliability, redundancy). The document has 681 terms defined. It is more a dictionary than a standard because there is no attempt to make the definitions mutually exclusive.

There is some duplication between the two standards. Thirty-one of the terms appearing in MIL-STD-721 also appear in MIL-STD-1309. However, only four of these terms have the same definitions in both documents. That is not necessarily to say that the two definitions are in conflict, just that they differ somewhat.

There are diagnostic and testability terms which are missing from both documents. Integrated Diagnostics is not defined, and terms (e. g., expert systems, knowledge engineering) are not included.

A major problem exists in defining the content of these two standards. On one hand, MIL-STD-721 does not include all of the terms relative to reliability and maintainability, if indeed diagnostics and testability are a subset. On the other hand, MIL-STD-1309C covers terms which not only apply to TMDE, but apply to many terms outside of its realm. Separating the two is very difficult. Reliability and maintainability overlap with testability and diagnostics and, if the components of diagnostics (i. e., testing, training, and technical information) are also depicted, the overlap becomes more confusing.

Thus, it does not seem that the separation, based on the titles of documents, appears realistic. Where testability and diagnostic terms should appear is also hazy.

TESTABILITY/DIAGNOSTIC IMPACT:

Conflicting terms and terms not defined both have a significant effect on understanding between the government and its contractors. Trying to define every reliability, maintainability, and diagnostic term appears unrealistic and could cause confusion by not standardizing on single terms in lieu of overlapping terms.

GENERAL RECOMMENDATIONS:

The NSIA Integrated Diagnostics Group recommended combining the two standards into one. Although this recommendation may have merit in the long run, it might prove to be difficult and time consuming.

Another alternative is to expand MIL-STD-721 to include preferred definitions, including those for testability and diagnostics, utilizing a mutually exclusive concept for these definitions. On the other hand, MIL-STD-1309 could be maintained as a dictionary of relative terms, much the same as it appears now, but assuring that there is no conflict in terms between the two standards.

SPECIFIC MODIFICATIONS:

An analysis of principal testability/diagnostic terms is shown in Figures 4-1 through 4-4. The terms are classified under four major headings: Availability (Measures); Diagnosis; Test; and, Diagnostic Capability. Each of the 71 terms depicted on these diagrams is keyed as follows:

1. The term is presently in MIL-STD-721C.

2. The term is presently in MIL-STD-1309C.

3. The term is not defined in either standard, but is a principal term.

	NO. OF PRINCIPAL TESTABILITY/DIAGNOSTIC TERMS
MIL-STD-721C	15
MIL-STD 1309C	43
NOT DEFINED	22
	90 *

* Nine of the terms appear in both standards.

It is recommended that 54 terms (34 from MIL-STD-1309 and 22 more not defined) be included in MIL-STD-721C and that this standard be the primary standard referenced in contractual documents relating to these types of definitions.

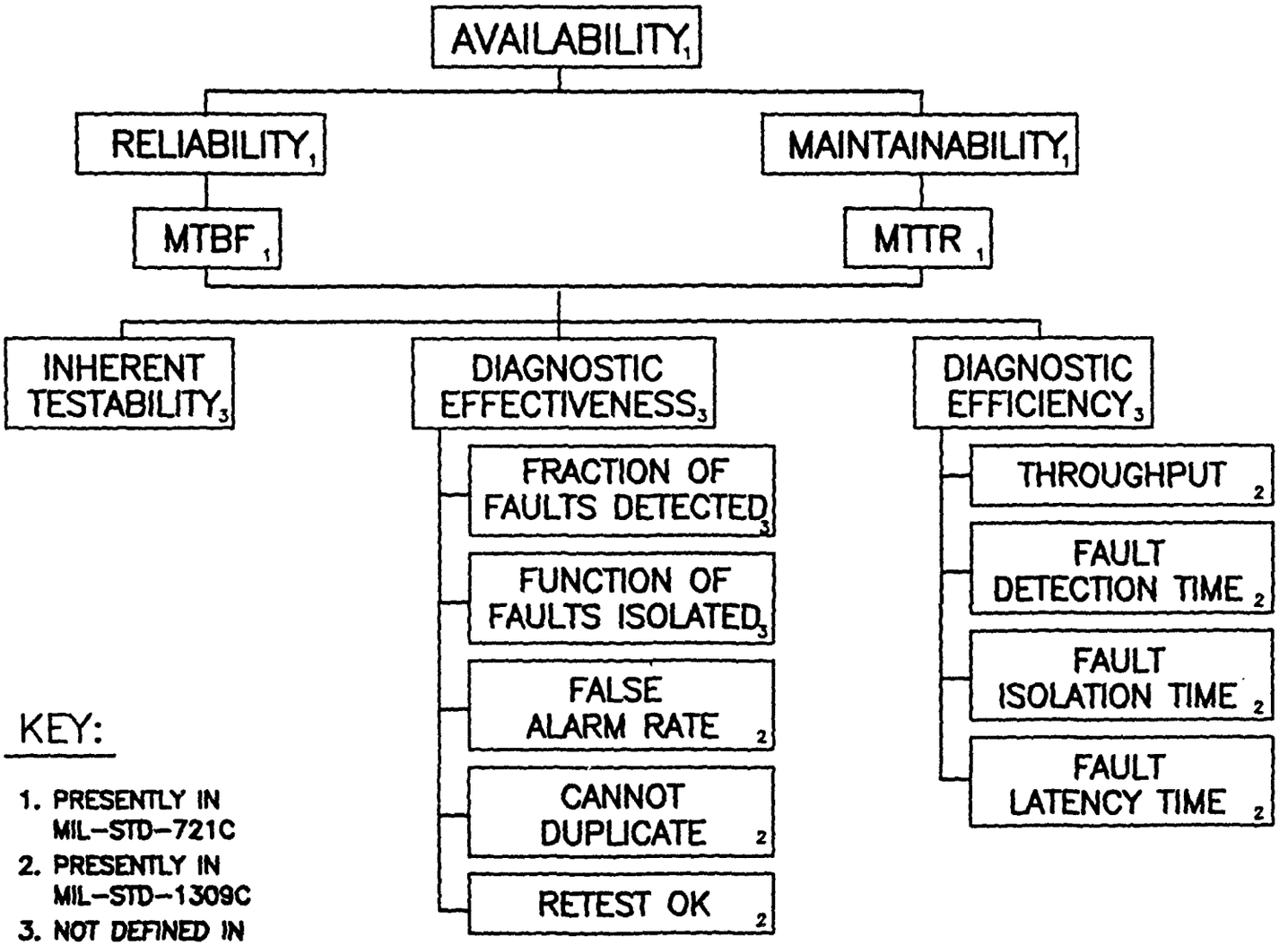


Figure 4-1. Analysis of Principal Terms - Availability

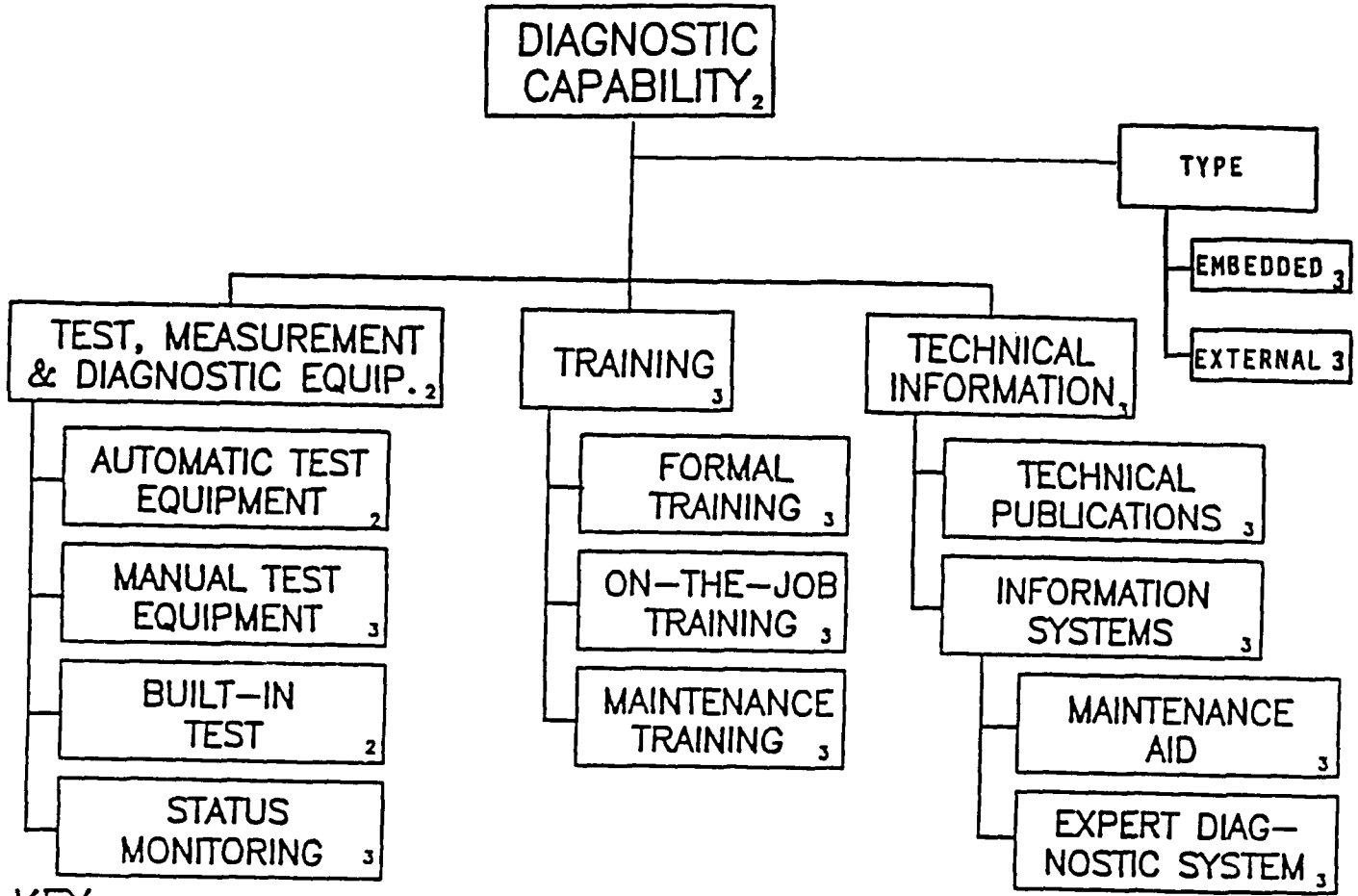


Figure 4-2. Analysis of Principal Terms - Diagnostic Capability

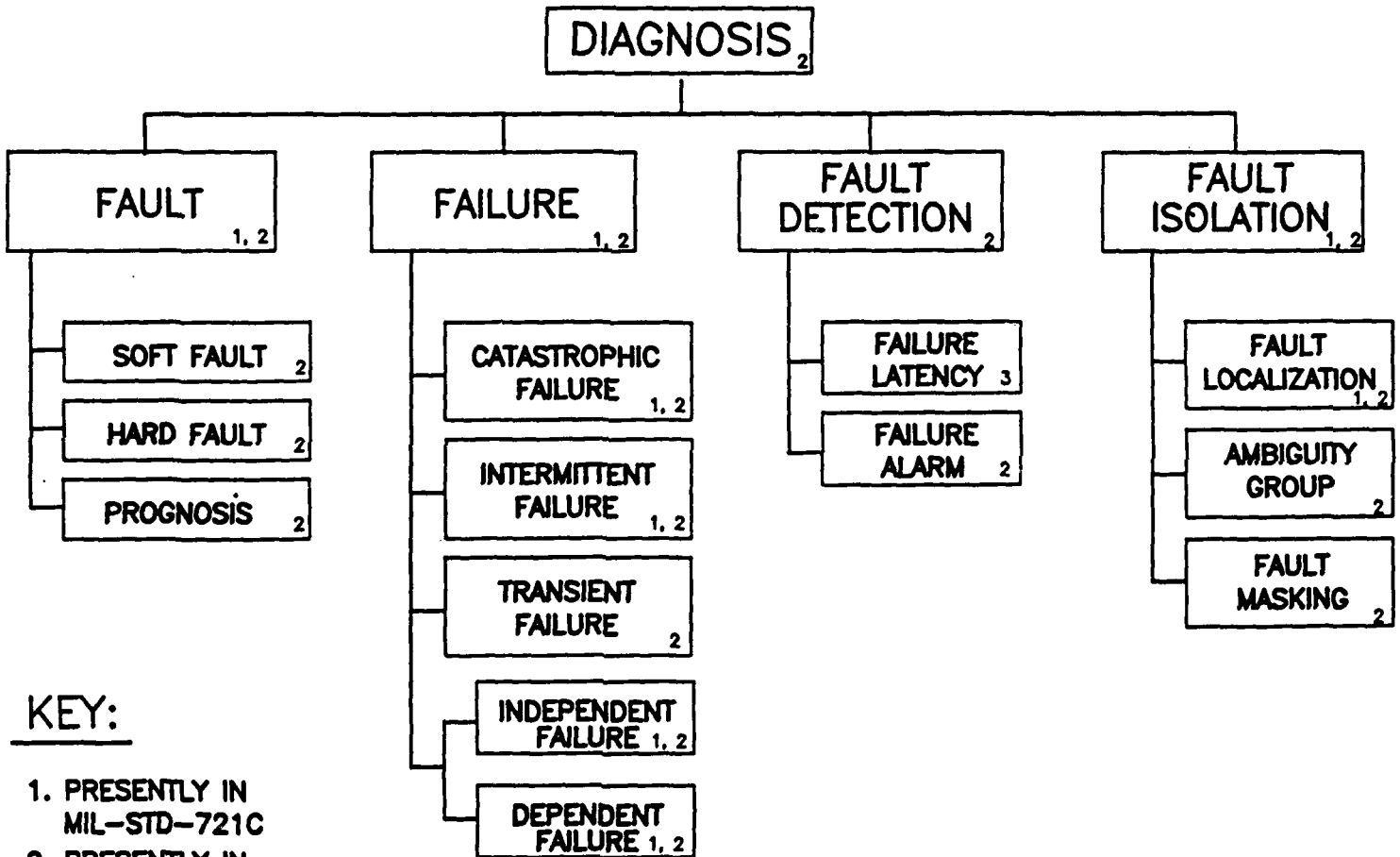


Figure 4-3. Analysis of Principal Terms - Diagnosis

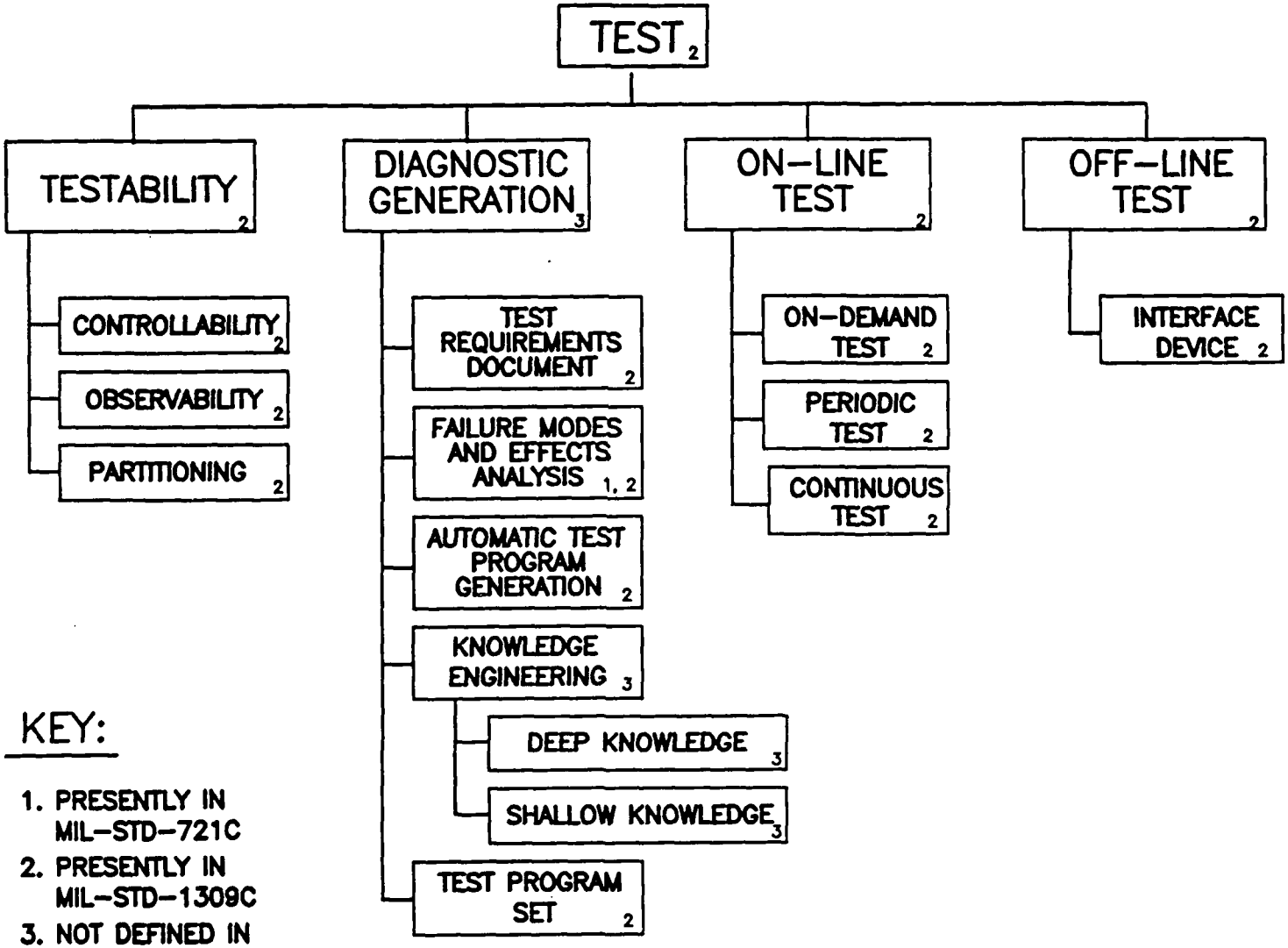


Figure 4-4. Analysis of Principal Terms - Test

V. SUMMARY.

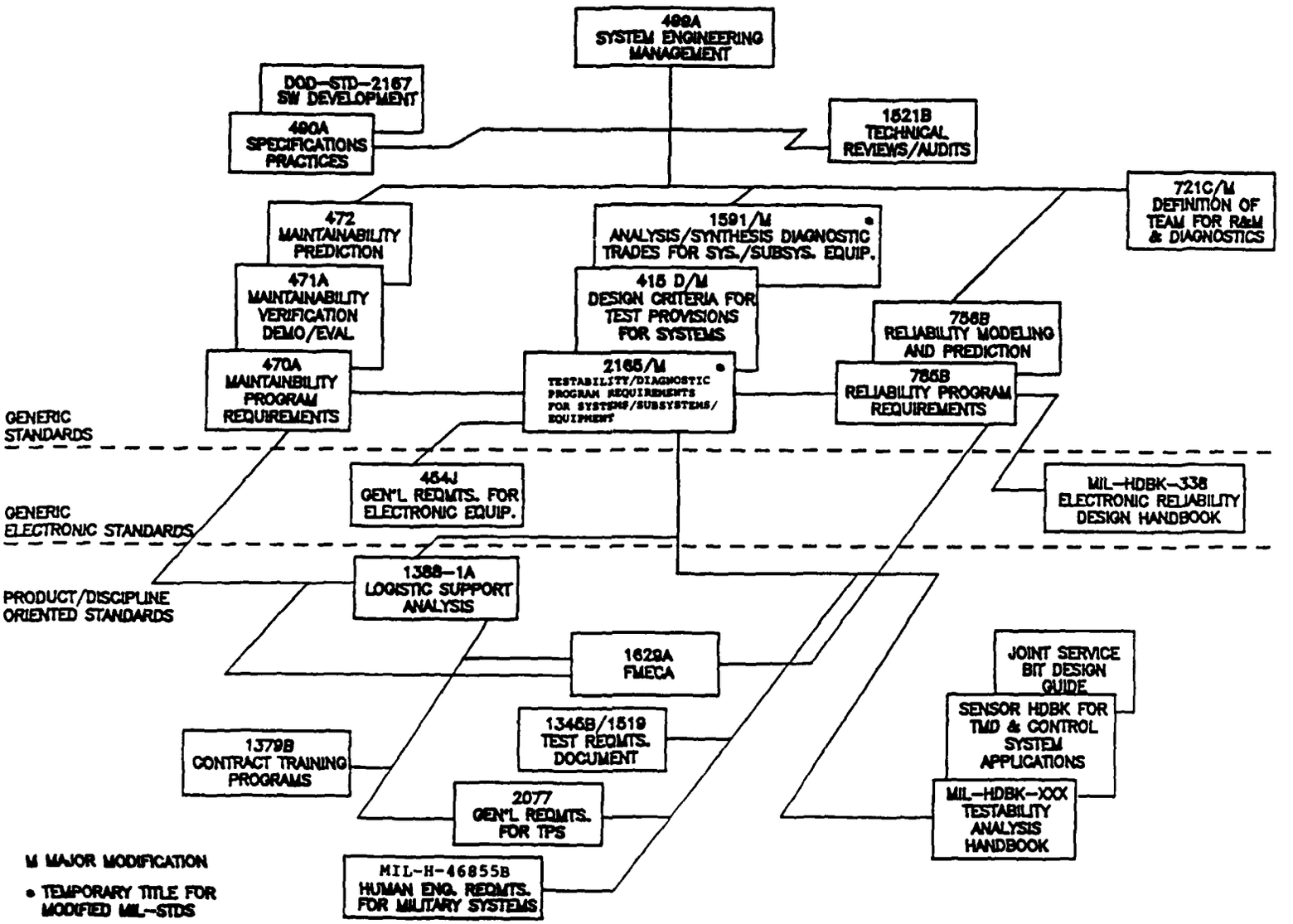
This report addresses the necessary modifications to 24 existing standards and handbooks required to assure the acquisition of an adequate weapon system diagnostic capability. The 24 standards/handbooks that have been recommended for testability/diagnostics-related modifications are shown in Table 5-1, Testability/Diagnostics-Related MIL-STDs Hierarchical Relationships. The table has been formulated and included to provide the following:

- The relationships of the standards to each other
- The depiction of the testability/diagnostics-related standards hierarchy, which includes generic standards, generic electronic standards, and product/discipline-oriented standards
- The relational impact that the standards recommended for major modification have on the hierarchy.

The modifications recommended for all the standards in Table 5-1 will provide a cohesive diagnostic design process that is implementable. The utilization of the standards during the integrated diagnostics process is shown in Appendix B.

This report provides a firm foundation for the proper implementation of both testability and diagnostics in the design and acquisition of weapon systems.

TABLE 5-1. TESTABILITY/DIAGNOSTICS RELATED MIL-STDS HIERARCHICAL RELATIONSHIPS



APPENDIX A

LISTING OF EXISTING AND PLANNED MILITARY STANDARDS, HANDBOOKS AND GUIDES APPLICABLE TO TESTABILITY AND DIAGNOSTICS

Table A-1 is a listing of existing and planned documents which conceivably relate to testability and diagnostics and which were incorporated in this analysis. As can be seen, these documents cover a wide variety of standardization areas, indicative of the testability and integrated diagnostics process. The sixteen (16) documents required as a minimum in the RADC Statement of Work for this contract are also identified.

The proposed disposition of each of the documents is also indicated. These categories are as follows:

- Major Revision -- Significant changes are required
- Minor Revision -- Changes include word and paragraph insertions and changes, without significantly changing the mission of the document
- No Action Required -- Document is satisfactory in its present form
- Recommend Canceling -- Cancellation or nonuse is recommended
- Guidance Required -- No change required. However, material in these documents should be incorporated in guidance for implementing the integrated diagnostics process.

TABLE A-1. LISTING OF EXISTING AND PLANNED DOCUMENTS

DOC.NO.	TITLE	STD. AREA	RADC SOW	DISPOSITION				
				MAJ. REV.	MIN. REV.	NO ACTION REQ'D	REC. CAN.	GUIDANCE REQ'd
MIL-STD-334(TM)	Displayed Messages For ATE	TMSS				X		
MIL-STD-415D	Test Provisions For Electronic Systems And Associated Equipment, Design Criteria For	MISC	X	X				
MIL-STD-454J	Standard General Requirements For Electronic Equipment	GDRQ	X		X			
MIL-STD-470A	Maintainability Program Requirements (For Systems And Equipment)	MNTY	X		X			
MIL-STD-471A	Maintainability Demonstration	MNTY	X	X				
DOD-STD-480A	Configuration Control - Engineering Changes, Deviations, And Waivers	CMAN				X		
MIL-STD-482A	Configuration Status Accounting Data Elements And Related Features	CMAN				X		
MIL-STD-483(USAF)	Configuration Management Practices For Systems, Equipment, Munitions, And Computer Programs	CMAN				X		
MIL-STD-490A	Specification Practices	CMAN			X			
MIL-STD-499A	Engineering Management	MISC			X			
MIL-STD-721C	Definitions Of Effectiveness Terms For Reliability, Maintainability, Human Factors, And Safety	RELI	X	X				
MIL-STD-756B	Reliability Modeling	RELI	X	X				

TABLE A-1. LISTING OF EXISTING AND PLANNED DOCUMENTS (Continued)

DOC.NO.	TITLE	STD. AREA	RADC SOW	DISPOSITION				
				MAJ. REV.	MIN. REV.	NO ACTION REQ'D	REC. CAN.	GUIDANCE REQ'd
MIL-STD-781C	Reliability Design Qualifications And Production Acceptance Tests: Exponential Distribution	RELI				X		
MIL-STD-785B	Reliability Program For Systems And Equipment Development And Production	RELI	X		X			
MIL-STD-790C	Reliability Assurance Program For Electronic Parts Specifications	RELI				X		
MIL-STD-881A	Work Breakdown Structures For Defense Materiel Items	MISC				X		
MIL-STD-882	System Safety Program Requirements	SAFT				X		
MIL-STD-883C	Test Methods And Procedures For Micro-Electronics	5962				X		
MIL-STD-1309C	Definition Of Terms For Test, Measurement, And Diagnostic Equipment	ATTS	X	X				
MIL-STD-1326	Test Point, Test Point Selection And Interface Requirements For Equipments Monitored By Shipboard On-Line Automatic Test Equipment	ATTS					X	
MIL-STD-1345B	Test Requirements Document, Preparation Of	MISC		X				
MIL-STD-1379B	Contract Training Programs	69GP			X			
MIL-STD-1388-1A	Logistic Support Analysis	ILSS	X		X			
MIL-STD-1390B	Level Of Repair	MISC	X			X		

TABLE A-1. LISTING OF EXISTING AND PLANNED DOCUMENTS (Continued)

DOC.NO.	TITLE	STD. AREA	RADC SOW	DISPOSITION				
				MAJ. REV.	MIN. REV.	NO ACTION REQ'D	REC. CAN.	GUIDANCE REQ'd
MIL-STD-1456(AR)	Contractor Configuration Management Plan	CMAN				X		
MIL-STD-1472C	Human Engineering Design Criteria For Military Systems, Equipment, And Facilities	HFAC				X		
MIL-STD-1519	Test Requirements Document, Preparation Of	MISC	X	X				
MIL-STD-1521A	Technical Reviews And Audits For Systems, Equipment, And Complete Programs	CMAN		X				
MIL-STD-1543A	Reliability Program Requirements For Space And Missile Systems	RELI				X		
MIL-STD-1591	On Aircraft, Fault Diagnosis, Subsystems, Analysis/Synthesis Of	MNTY		X				
MIL-STD-1629A	Procedures For Performing A Failure Mode, Effects, And Criticality Analysis	RELI	X		X			
MIL-STD-1635	Reliability Growth Testing	RELI						X
MIL-STD-1678	Fiber Optics Test Methods And Instrumentation	9999				X		
DOD-STD-1685(SH)	Comprehensive Standards For Technical Manuals (Metric)	TMSS				X		
DOD-STD-1701	Hardware Diagnostic Test Systems Requirements	ATTS					X	
MIL-STD-1752	Reading Level Requirements For Preparation Of Technical Orders	TMSS				X		
MIL-STD-1760	Aircraft/Store Electrical Interconnection System	GDRQ				X		

TABLE A-1. LISTING OF EXISTING AND PLANNED DOCUMENTS (Continued)

DOC.NO.	TITLE	STD. AREA	RADC SOW	DISPOSITION				
				MAJ. REV.	MIN. REV.	NO ACTION REQ'D	REC. CAN.	GUIDANCE REQ'd
MIL-STD-1843 (USAF)	Reliability-Centered Maintenance For Aircraft, Engines, And Equipment	ILSS				X		
MIL-STD-2068	Reliability Development Tests	RELI				X		
MIL-STD-2074(AS)	Failure Classification For Reliability Testing	RELI				X		
MIL-STD-2076	Unit Under Test Compatibility With Automatic Test Equipment, General Requirements For	MISC					X	
MIL-STD-2077	Test Program Sets, General Requirements For	MISC			X			
MIL-STD-2080(AS)	Maintenance Plan Analysis For Aircraft And Ground Support Equipment	MISC					X	
MIL-STD-2084(AS)	Maintainability Of Avionic And Electronic Systems And Equipment, General Requirements For	MNTY	X				X	
DOD-STD-2121	Determination Of Electronic Test Equipment Parameters	6625				X		
MIL-STD-2155(AS)	Failure Reporting Analysis And Corrective Action System	RELI						X
MIL-STD-2164(EC)	Environment Stress Screening Process For Electronic Equipment	RELI				X		
MIL-STD-2165	Testability Program For Electronic Systems And Equipments	ATTS	X	X				
DOD-STD-2167	Defense System Software Development	MCCR			X			
DOD-STD-2168	Software Quality Evaluation	QCIC/ MCCR/ IPSC				X		

TABLE A-1. LISTING OF EXISTING AND PLANNED DOCUMENTS (Continued)

DOC.NO.	TITLE	STD. AREA	RADC SOW	DISPOSITION				
				MAJ. REV.	MIN. REV.	NO ACTION REQ'D	REC. CAN.	GUIDANCE REQ'd
MIL-STD-45662	Calibration System Requirements	QCIC				X		
MIL-H-46855B	Human Engineering Requirements For Military Systems, Equipment, And Facilities	HFAC		X				
MIL-M-87153 (USAF)	Manuals, Technical: Operator Test Procedures Manuals Using Automatic Test Equipment	TMSS				X		
MIL-STD-XXX (RELI-0026)	Bayesian Reliability Demonstration	RELI				X		

TABLE A-1. LISTING OF EXISTING AND PLANNED DOCUMENTS (Continued)

DOC.NO.	TITLE	STD. AREA	RADC SOW	DISPOSITION				
				MAJ. REV.	MIN. REV.	NO ACTION REQ'D	REC. CAN.	GUIDANCE REQ'd
MIL-HDBK-189	Reliability Growth Management	RELI				X		
MIL-HDBK-217E	Reliability Prediction Of Electronic Equipment	RELI				X		
MIL-HDBK-266(AS)	Application Of Reliability-Centered Maintenance To Naval Aircraft, Weapon Systems, And Support Equipment	MISC				X		
MIL-HDBK-276-2(MC)	LCC Model For Defense Materiel Systems Operating Instructions	MISC				X		
MIL-HDBK-300(M)	Technical Information File Of Support Equipment	MISC				X		
MIL-HDBK-333(USAF) VOLS 1&2	Handbook For Standardization Of Non-Destructive Testing Methods	NDTI				X		
MIL-HDBK-338 VOLS 1&2	Electronic Reliability Design Handbook	RELI	X	X				
MIL-HDBK-472	Maintainability Prediction	MNTY	X			X		
MIL-HDBK-759	Human Factors Engineering Design For Army Materiel	HFAC				X		
MIL-HDBK-761	Human Engineering Guidelines For Management Information Systems	HFAC				X		
MIL-HDBK-781	Reliability Growth Management	RELI				X		
MIL-HDBK-63038-1A (TM)	Technical Manual Writing Handbook	TMSS				X		
MIL-HDBK-63038-2A (TM)	Technical Writing Style Guide	TMSS				X		

TABLE A-1. LISTING OF EXISTING AND PLANNED DOCUMENTS (Continued)

DOC.NO.	TITLE	STD. AREA	RADC SOW	DISPOSITION				
				MAJ. REV.	MIN. REV.	NO ACTION REQ'D	REC. CAN.	GUIDANCE REQ'd
MIL-HDBK-XXX (RELI-0008)	Testability Analysis Handbook	MNTY						X
MIL-HDBK-XXX (RELI-0034)	Non-Electronic Reliability Handbook	RELI				X		
MIL-HDBK-XXX (RELI-0042)	System Hardware/Software Reliability	RELI				X		
	Selection Guide For Digital Test Program Generation Systems					X		
	Joint Service Weapon System Acquisition Review Guidelines For Automatic Test							X
	Built-In Test Design Guide			X				
	Joint Service Automatic Testing (AT) Acquisition Planning Guide							X
	Sensor Handbook			X				
	Maintainability Costing Information	MNTY				X		
	Testability Methods Handbook	MNTY						X
MIL-HDBK-XXX (MNTY-8003)	Design Handbook For Maintainability (Electronics)	MNTY				X		
MIL-HDBK-XXX (MNTY-8004)	Design Handbook for Maintainability (Mechanical)	MNTY				X		
MIL-HDBK-XXX (HFAC-027)	Human Engineering Procedures Guide	HFAC						X

APPENDIX B

DETAILED APPROACH

1.0 SCOPE.

This appendix contains the top-down approach used for determining documentation requirements.

1.1 Purpose.

The purpose of this appendix is to outline the approach and methodology used to show relevance of the MIL-STDs, MIL-HDBKs, and MIL-SPECs selected for review in this report to the diagnostic activities of the integrated diagnostic process.

2.0 APPROACH.

A top-down approach was used for determining documentation requirements for Phases I and II and for developing Phase III modifications.

2.1 Document Relationship to Weapon System Life Cycle Phases.

During Phase I, the format used for determining these relationships is shown in Figure B-1, MIL-STD/HDBK Relation to Weapon System Life Cycle. The major programmatic standards, which are task-oriented, are tied to the weapon system life cycle and each task delineated in relation to this life cycle.

The diagnostic and testability activities are then depicted in relation to the weapon system life cycle and to the tasks described in the programmatic standards. These diagnostics and testability activities were established using the Integrated Computer-Aided Manufacturing Definition (IDEF 0) process, which grew out of the Integrated Computer-Aided Manufacturing System (ICAM). This process, although developed for ICAM, can be applied toward the planning of most any program. As shown in Figure B-2, for each diagnostic/testability activity, there are inputs and outputs. There are controls over this activity, such as military standards. There are mechanisms which can aid in

	DOCUMENT	WEAPON SYSTEM LIFE CYCLE					
		PRECONCEPTUAL	CONCEPT EXPLORATION	DEMONSTRATION AND VALIDATION	FULL-SCALE DEVELOPMENT	PRODUCTION	DEPLOYMENT
PROGRAMMATIC STANDARDS	MIL-STD-499						
	MIL-STD-1388						
	MIL-STD-785						
	MIL-STD-470						
	MIL-STD-2165						
DIAGNOSTICS/TESTABILITY	ACTIVITY FLOW CHARTS						
GUIDANCE DOCUMENTATION	RADC TESTABILITY NOTEBOOK						
	MATE TESTABILITY GUIDE						

Figure B-1. MIL-STD/HDBK Relation to Weapon System Life Cycle

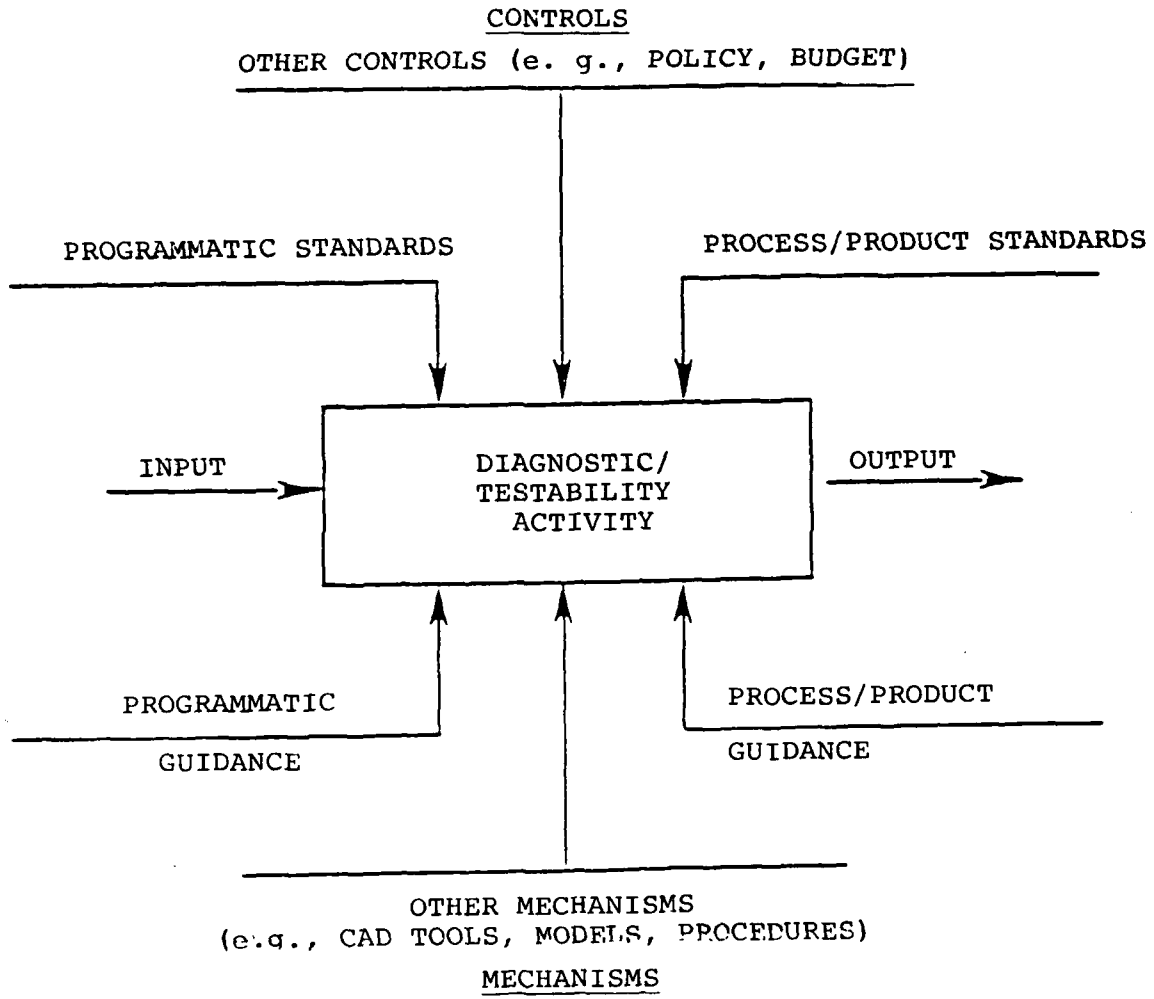


Figure B-2. Defining Testability/Diagnostics Activities Utilizing the IDEF 0 Process

performing this activity, such as military handbooks. In this manner, IDEF 0 was used to determine the standard and handbook requirements. Note that programmatic, as well as process or product type, documents are addressed.

This same format was used during Phase II as a basis for comparison of existing and planned standards and handbooks, with the requirements established under Phase I of the program. This entire process (the diagnostic/testability activities and the applicable documents for these activities) is contained in the Integrated Diagnostics Process Roadmap included in Section 2.4 of this appendix.

2.2 Integrated Diagnostics Process.

The Integrated Diagnostics Process Roadmap contains the system engineering activities that have a relationship to the implementation of diagnostics into weapon systems, prime system, subsystems, equipment, and their associated support systems. Therefore, the process described in this appendix, when used concurrently with an emerging system, subsystem, or equipment, defines the requirements for specifying diagnostics; allocating diagnostics to system, subsystem, and unit levels; identifying testability/diagnostic tasks; designing the diagnostic capability; conducting design reviews and audits; assuring the delivery of an adequate diagnostic capability; and collecting and analyzing data on the performance of the diagnostic capability.

2.2.1 Roadmap Purpose.

The purpose of the roadmap is to show the relevance of the MIL-STDs, MIL-HDBKs, and MIL-SPECs selected for review in this report to the diagnostic activities contained in the roadmap. An analysis of the match-up between the documents and the diagnostic activities will identify "gaps" and "shortfalls" in the documents relative to the implementation of the Integrated Diagnostics process.

2.2.2 Analysis Methodology.

The determination of document gaps and shortfalls is a two-step process.

STEP (1) -- Analyze the Integrated Diagnostics Process Roadmap Activities for the absence of MIL-STDs and/or MIL-HDBKs. Determine for a particular activity the need for MIL-STD and/or MIL-HDBK.

STEP (2) -- For each activity, the sufficiency of the requirements contained in the MIL-STD and MIL-HDBK for that particular activity must be evaluated. This has been accomplished through the use of Document Improvement Report sheets for each selected document, which are contained in Appendix D.

2.2.2.1 Analysis Results.

The results of the analysis are as follows:

CONCEPTUAL PHASE:

Activities A123 to A1235	--	One programmatic standard is needed which addresses all the testability/diagnostic elements.
Activity A1235	--	Guidance for determining the T/D impact on producibility and manufacturing is needed in a standard or handbook.
Activity A1242	--	MIL-STD-1521B should be revised to address diagnostics during System Requirements Review (SRR).

DEMONSTRATION & VALIDATION PHASE:

Activities A134 to A1346	--	One programmatic standard is needed which addresses all the testability/diagnostic elements.

Activity A1342 A1346 -- Guidance for incorporating diagnostic parametric values into systems, subsystems, and support systems should be provided in standards and/or handbooks.

Activity A1344 -- The impact of new technologies and new system architectures on the weapon system's entire diagnostic capability must be addressed.

Activity A13444 -- T/D Segments for Logistic Support Modeling -- Guidance should be included in a handbook.

Activity A1362 -- T/D Risk Areas Assessment and Technology Assessment -- guidance for performing T/D risk and technology assessment is needed in a standard and/or handbook.

Activity A1352 -- MIL-STD-1521B should be revised to include diagnostic review during System Design Review (SDR).

FULL-SCALE ENGINEERING DEVELOPMENT PHASE:

Activity A14311 -- One programmatic standard is needed to address all the testability/diagnostic elements.

Activity A14312 -- Guidance is required to conduct diagnostic element tradeoffs for optimization of diagnostic capability and weapon system design.

Activity A143113 -- Diagnostic Parametric Values impact on Technical Information. Guidance is required in standards and handbooks.

Activity A143114 -- Diagnostic Parametric Values impact on Manpower and Training. Guidance is required in standards and handbooks.

Activity A143115 -- Diagnostic Design Criteria Guidance is needed to determine the impact of on-line diagnostic decisions on off-line testing requirements.

Activity A1432 -- Diagnostic Data Collection -- All the programmatic standards mention data collection but none address the specific data collection requirements for diagnostics. Guidance material on specific data required must be prepared.

Activity A1433 -- MIL-STD-1521B must be revised to identify diagnostic-specific review items.

Activity A1435 -- Diagnostics Design Impact on Prime System Mission Availability -- Standards listed address mission availability without providing any details. Guidance to determine diagnostics impact on mission availability is needed in a handbook.

Activity A1437 -- MIL-STD-1521B must be revised to identify diagnostic-specific review items.

Activity A148 -- Maintenance Aids Requirements -- Guidance for addressing diagnostic parametric value selection on maintenance aid requirements should be included in a standard or handbook.

PRODUCTION PHASE:

Activity A25 -- Diagnostic Performance Assessment

Activity A251 -- Diagnostic Data Collection and Maturation -- More detailed guidance for diagnostic data collection and performance assessment during production is needed.

DEPLOYMENT PHASE:

Activity A342 -- Diagnostic Data Base Requirements -- The requirements must be defined and included in a handbook.

2.3 Conclusions.

From the analysis of the Integrated Diagnostics Process Roadmap activities, the following conclusions were formulated.

1. The programmatic standards, while addressing all of the diagnostic issues fragment the integrated diagnostic process so that the process for developing the diagnostic capability is not readily apparent and difficult to implement.

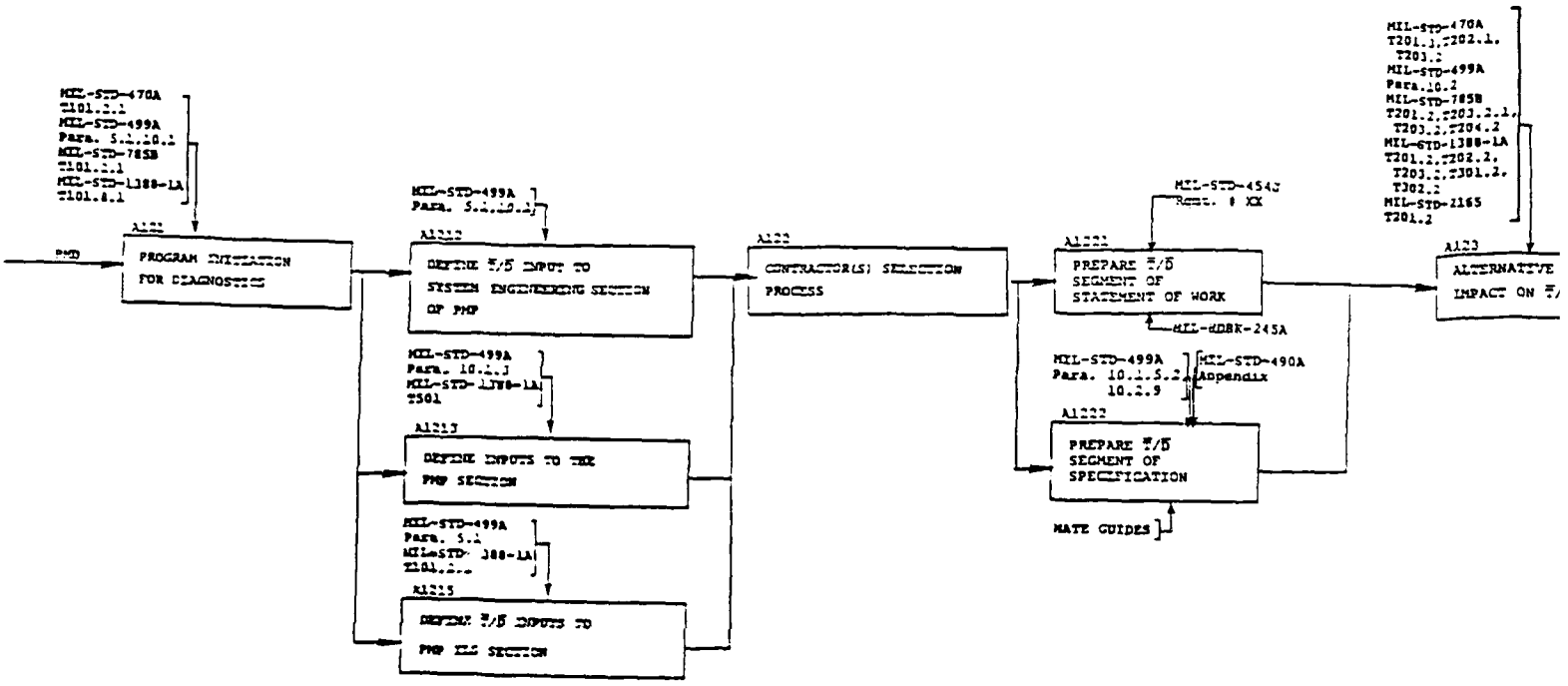
2. The activities identified above which indicate a gap or a shortfall in process/product oriented standards and handbooks could be corrected through the implementation of planned handbooks and the modification/revision of existing process/product oriented standards and handbooks.

3. The Integrated Diagnostics Process Roadmap should be used as the foundation for defining and providing guidance for the implementation of the Integrated Diagnostics Process.

2.4 Integrated Diagnostics Process Roadmap.

Figures B-3 through B-8 are the Roadmap Flow Charts.

CONCEPTUAL PHASE INTEGRATED DIAGNOSTIC PROCESS ACTIVITIES



T

IVITIES THAT REQUIRE ASSOCIATED MIL-STDs/MIL-HDBKs

IS

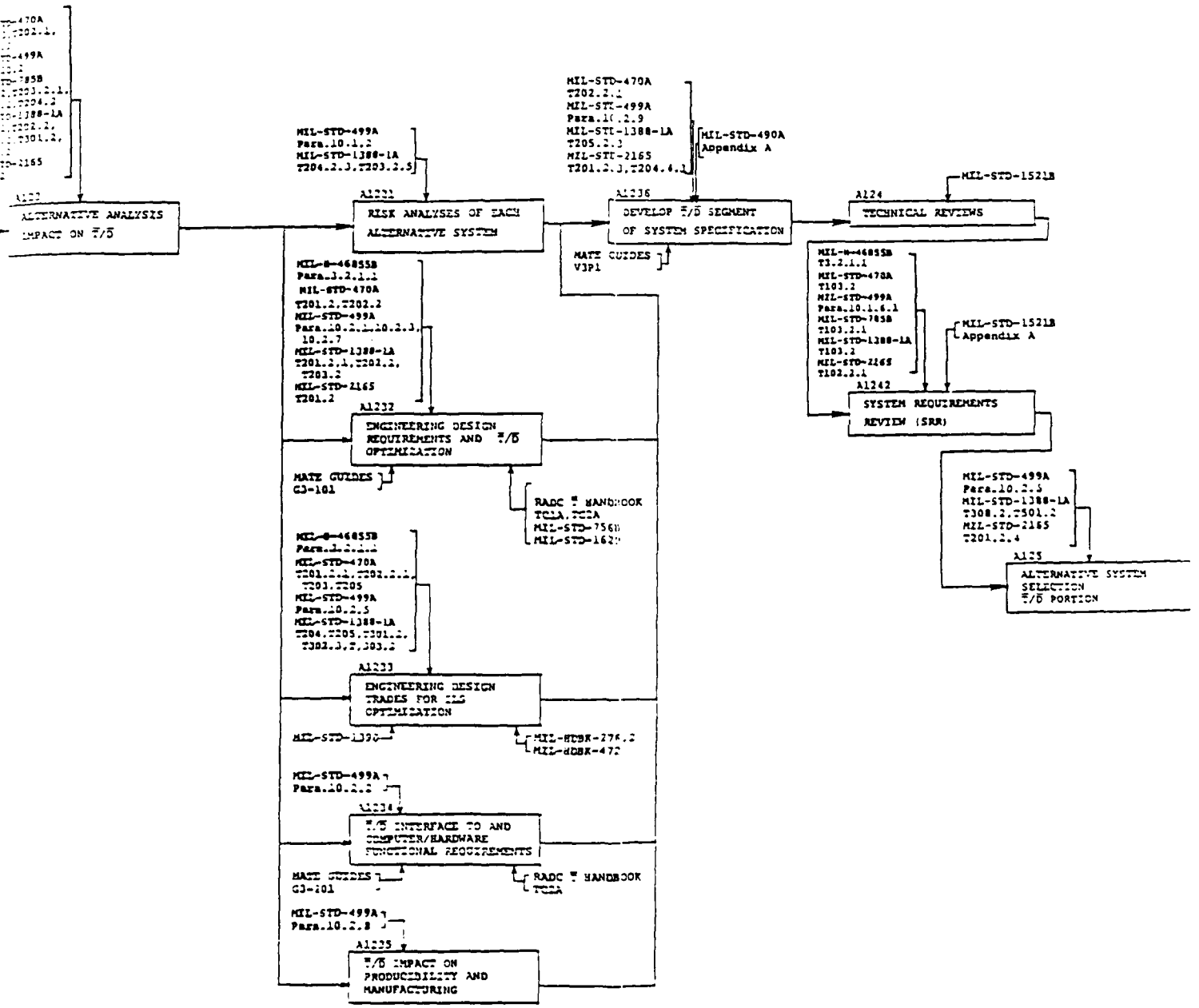
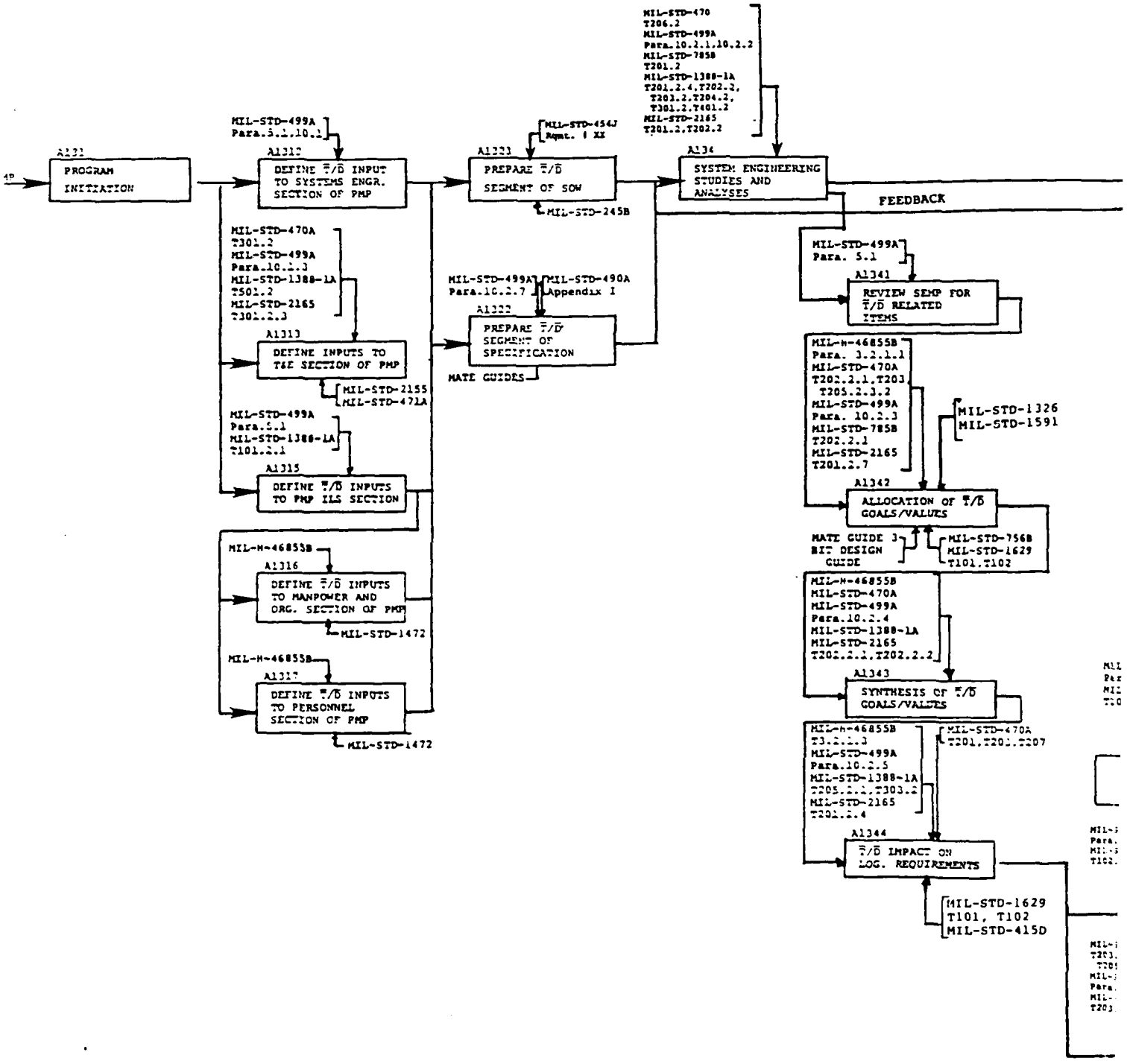


Figure B-3. Conceptual Phase Integrated Diagnostics (ID) Process

DEMONSTRATION & VALIDATION PHASE INTEGRATED DIAGNOSTIC PROC



PROCESS ACTIVITIES THAT REQUIRE ASSOCIATED MIL-STDs/MIL-HDBKs

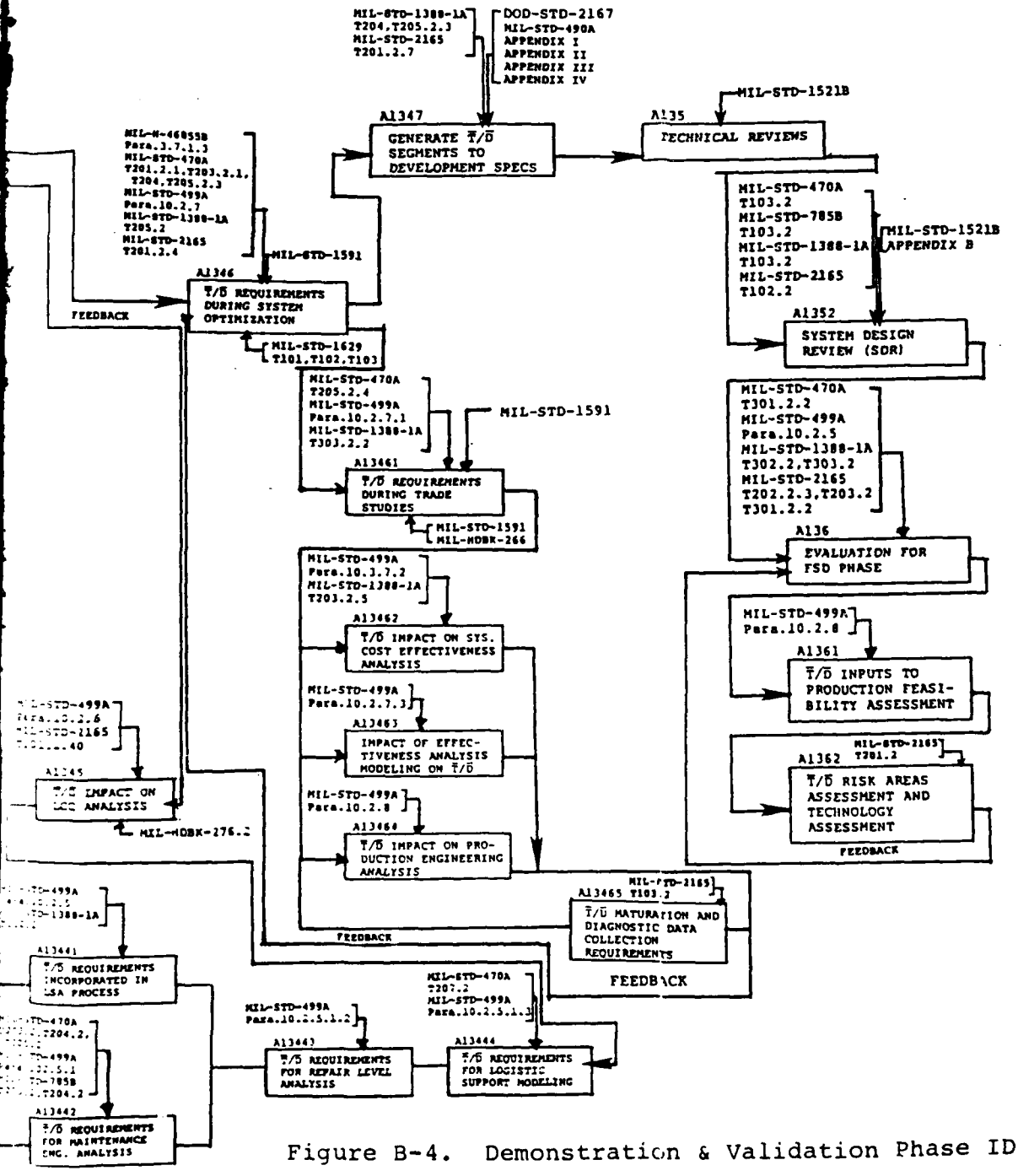
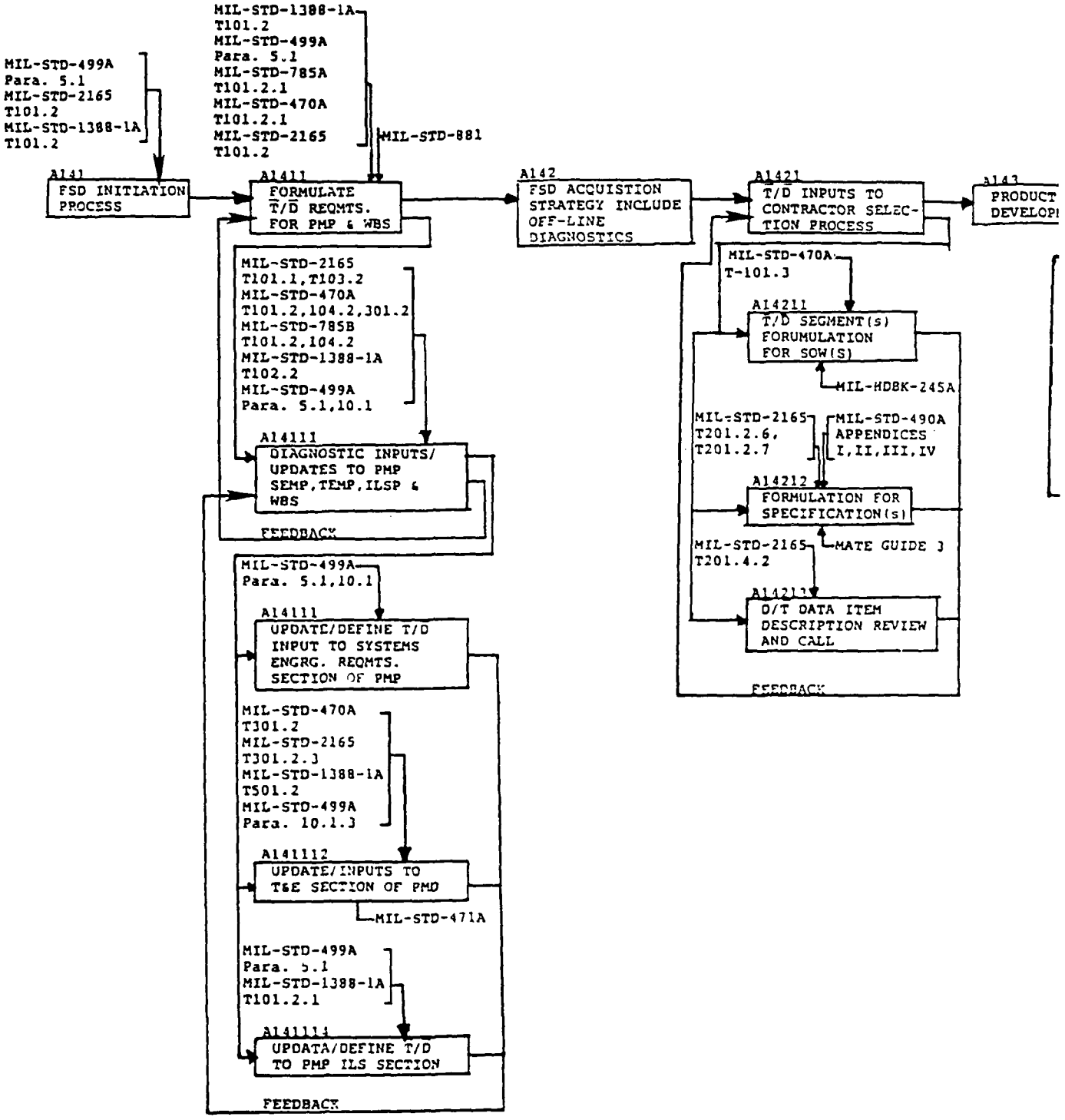


Figure B-4. Demonstration & Validation Phase ID Process


MIL-STD-499A
Para. 5.1
MIL-STD-2165
T101.2
MIL-STD-1388-1A
T101.2
MIL-STD-1388-1A
T101.2
MIL-STD-499A
Para. 5.1
MIL-STD-785A
T101.2.1
MIL-STD-470A
T101.2.1
MIL-STD-2165
T101.2
MIL-STD-881
A141
FSD INITIATION PROCESS
A1411
FORMULATE T/D REQMTS. FOR PMP & WBS
A142
FSD ACQUISTION STRATEGY INCLUDE OFF-LINE DIAGNOSTICS
A1421
T/D INPUTS TO CONTRACTOR SELECTION PROCESS
A143
PRODUCT DEVELOPI
MIL-STD-2165
T101.1,T103.2
MIL-STD-470A
T101.2,104.2,301.2
MIL-STD-785B
T101.2,104.2
MIL-STD-1388-1A
T102.2
MIL-STD-499A
Para. 5.1,10.1
A14111
DIAGNOSTIC INPUTS/ UPDATES TO PMP SEMP,TEMP,ILSP & WBS
FEEDBACK
MIL-STD-499A
Para. 5.1,10.1
A14111
UPDATE/DEFINE T/D INPUT TO SYSTEMS ENGRG. REQMTS. SECTION OF PMP
MIL-STD-470A
T301.2
MIL-STD-2165
T301.2.3
MIL-STD-1388-1A
T501.2
MIL-STD-499A
Para. 10.1.3
A141112
UPDATE/INPUTS TO T&E SECTION OF PMD
MIL-STD-471A
MIL-STD-499A
Para. 5.1
MIL-STD-1388-1A
T101.2.1
A141111
UPDATA/DEFINE T/D TO PMP ILS SECTION
FEEDBACK
MIL-STD-470A
T-101.3
A14211
T/D SEGMENT(s) FORUMULATION FOR SOW(S)
MIL-HDBK-245A
MIL-STD-2165
T201.2.6,
T201.2.7
MIL-STD-490A
APPENDICES
I,II,III,IV
A14212
FORMULATION FOR SPECIFICATION(s)
MIL-STD-2165
T201.4.2
MATE GUIDE 3
A14213
D/T DATA ITEM DESCRIPTION REVIEW AND CALL
FEEDBACK

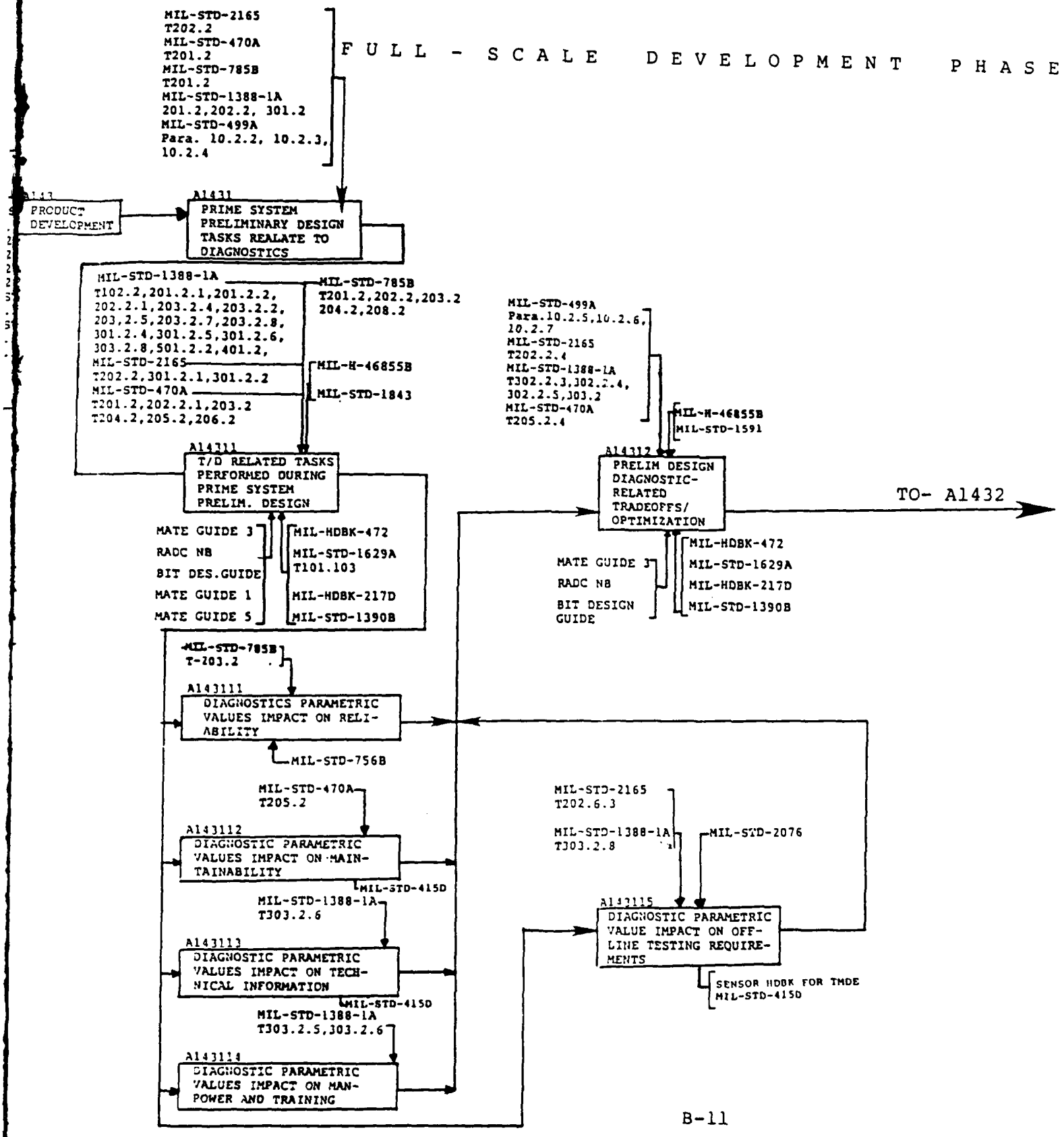
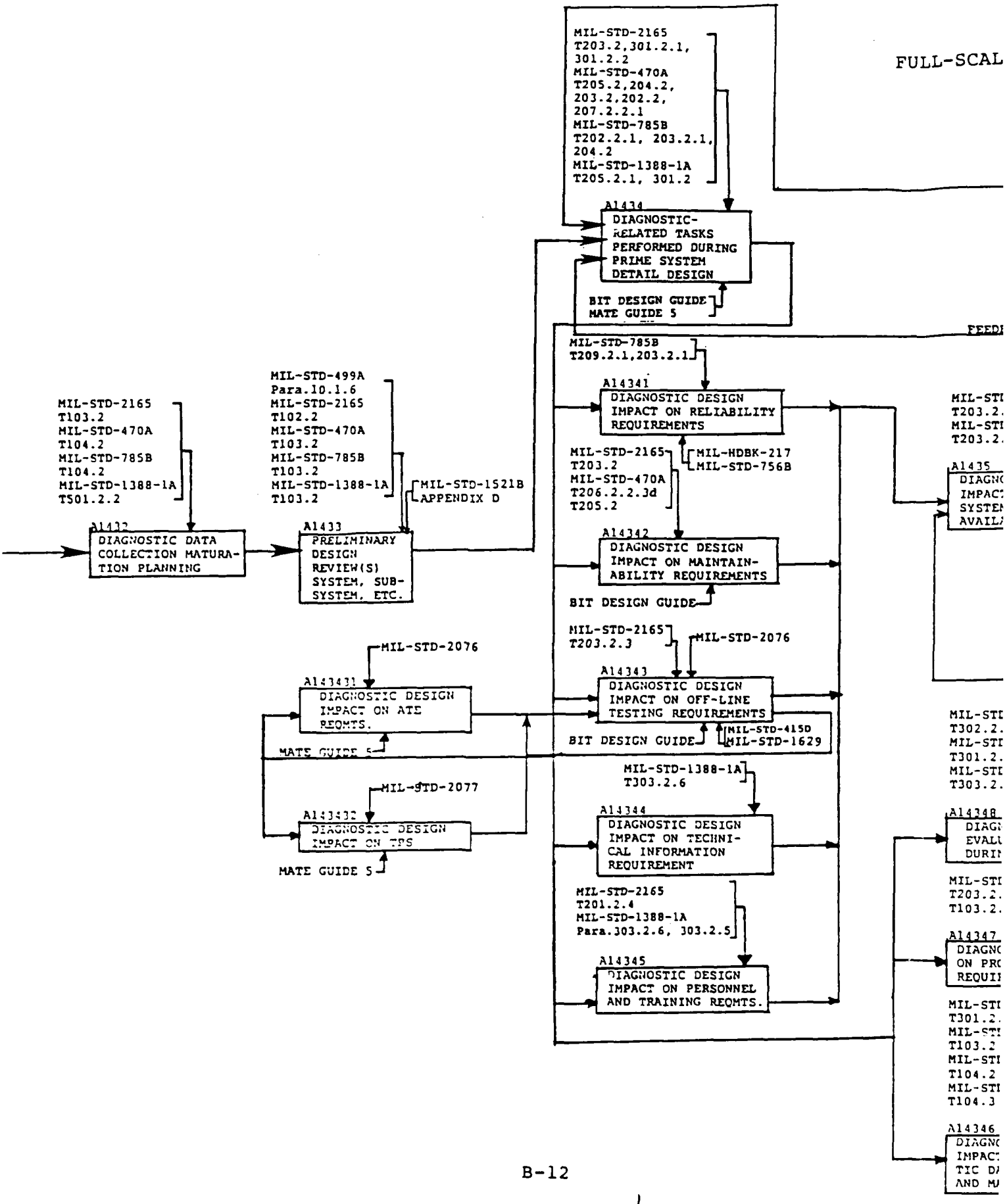


Figure B-5. Demonstration & Validation Phase And Full-Scale Development Phase Integrated Diagnostics Process


FULL-SCAL
MIL-STD-2165
T203.2,301.2.1,
301.2.2
MIL-STD-470A
T205.2,204.2,
203.2,202.2,
207.2.2.1
MIL-STD-785B
T202.2.1, 203.2.1,
204.2
MIL-STD-1388-1A
T205.2.1, 301.2
A1434
DIAGNOSTIC-RELATED TASKS PERFORMED DURING PRIME SYSTEM DETAIL DESIGN
BIT DESIGN GUIDE
MATE GUIDE 5
FEEDI
MIL-STD-785B
T209.2.1,203.2.1
A14341
DIAGNOSTIC DESIGN IMPACT ON RELIABILITY REQUIREMENTS
MIL-HDBK-217
MIL-STD-756B
MIL-STD-2165
T203.2
MIL-STD-470A
T206.2.2.3d
T205.2
A14342
DIAGNOSTIC DESIGN IMPACT ON MAINTAIN-ABILITY REQUIREMENTS
BIT DESIGN GUIDE
MIL-STD-2165
T203.2.3
MIL-STD-2076
A14343
DIAGNOSTIC DESIGN IMPACT ON OFF-LINE TESTING REQUIREMENTS
MIL-STD-415D
MIL-STD-1629
BIT DESIGN GUIDE
MIL-STD-1388-1A
T303.2.6
A14344
DIAGNOSTIC DESIGN IMPACT ON TECHNI-CAL INFORMATION REQUIREMENT
MIL-STD-2165
T201.2.4
MIL-STD-1388-1A
Para.303.2.6, 303.2.5
A14345
DIAGNOSTIC DESIGN IMPACT ON PERSONNEL AND TRAINING REQMTS.
MIL-STD-499A
Para.10.1.6
MIL-STD-2165
T102.2
MIL-STD-470A
T103.2
MIL-STD-785B
T103.2
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T103.2
MIL-STD-1521B
APPENDIX D
MIL-STD-2165
T103.2
MIL-STD-470A
T104.2
MIL-STD-785B
T104.2
MIL-STD-1388-1A
T501.2.2
A1432
DIAGNOSTIC DATA COLLECTION MATURA-TION PLANNING
A1433
PRELIMINARY DESIGN REVIEW(S) SYSTEM, SUB-SYSTEM, ETC.
MIL-STD-2076
A143431
DIAGNOSTIC DESIGN IMPACT ON ATE REQMTS.
MATE GUIDE 5
MIL-STD-2077
A143432
DIAGNOSTIC DESIGN IMPACT ON TPS
MATE GUIDE 5
A1435
A14348
A14347
A14346

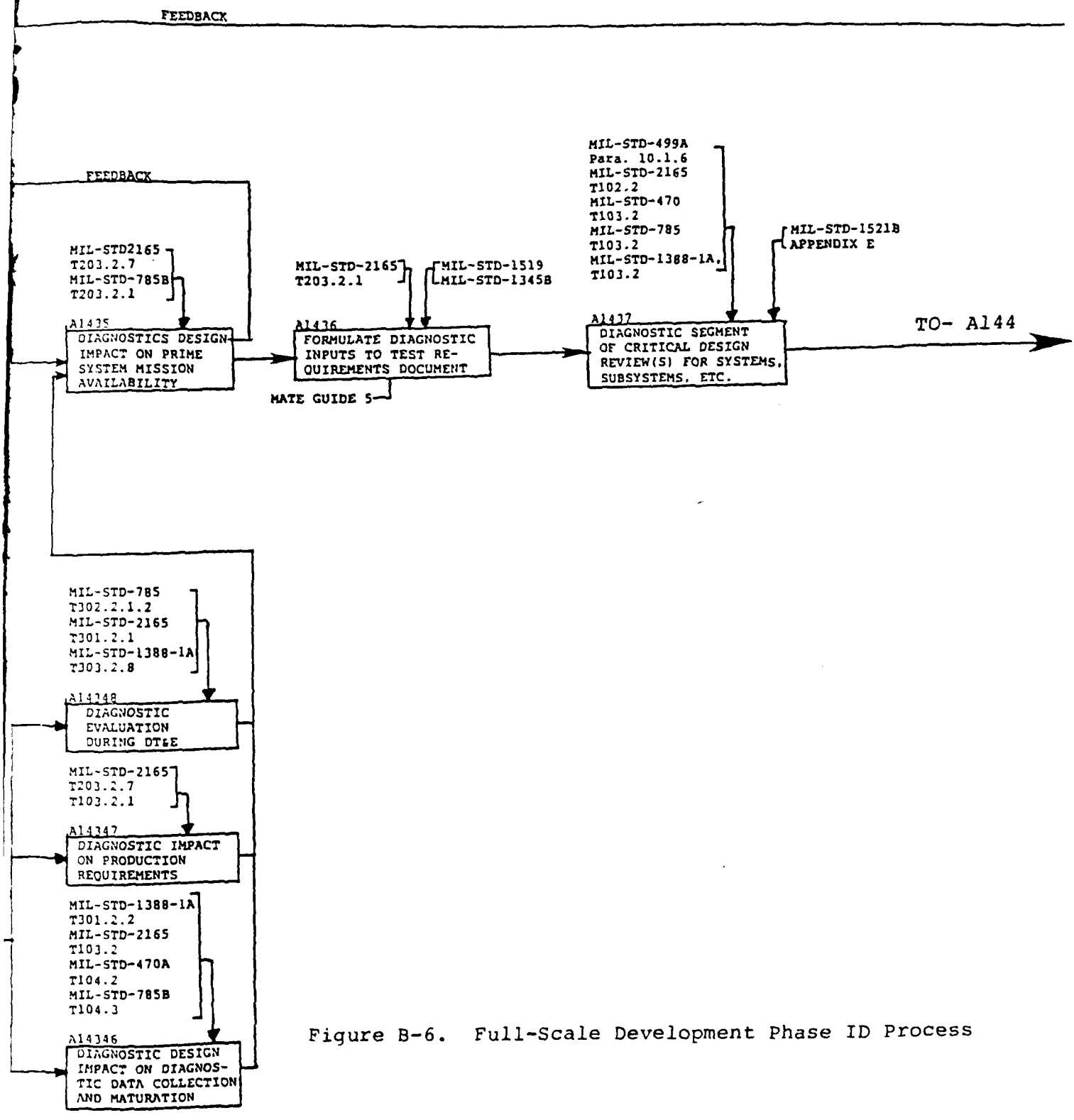
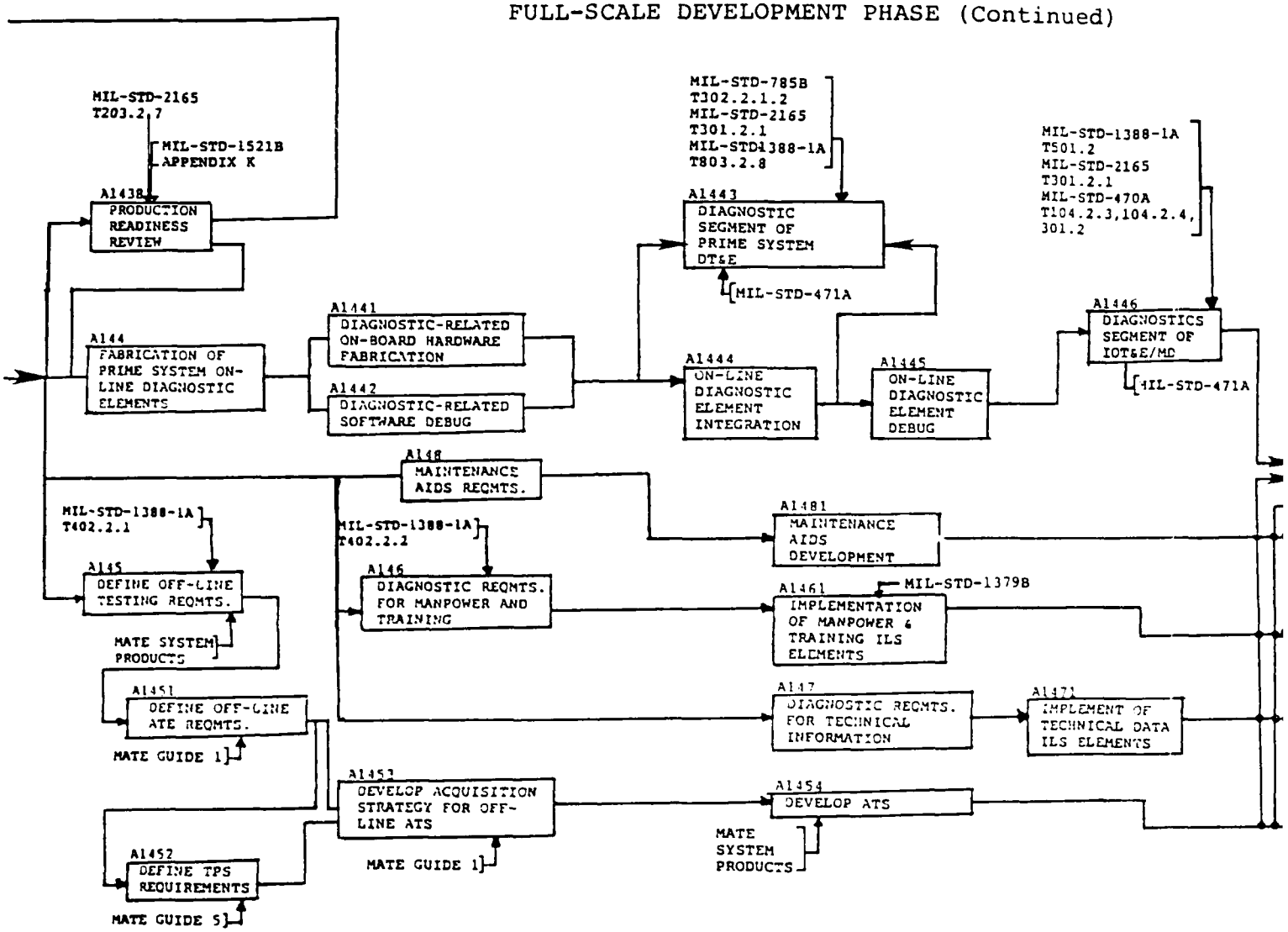


Figure B-6. Full-Scale Development Phase ID Process

FULL-SCALE DEVELOPMENT PHASE (Continued)



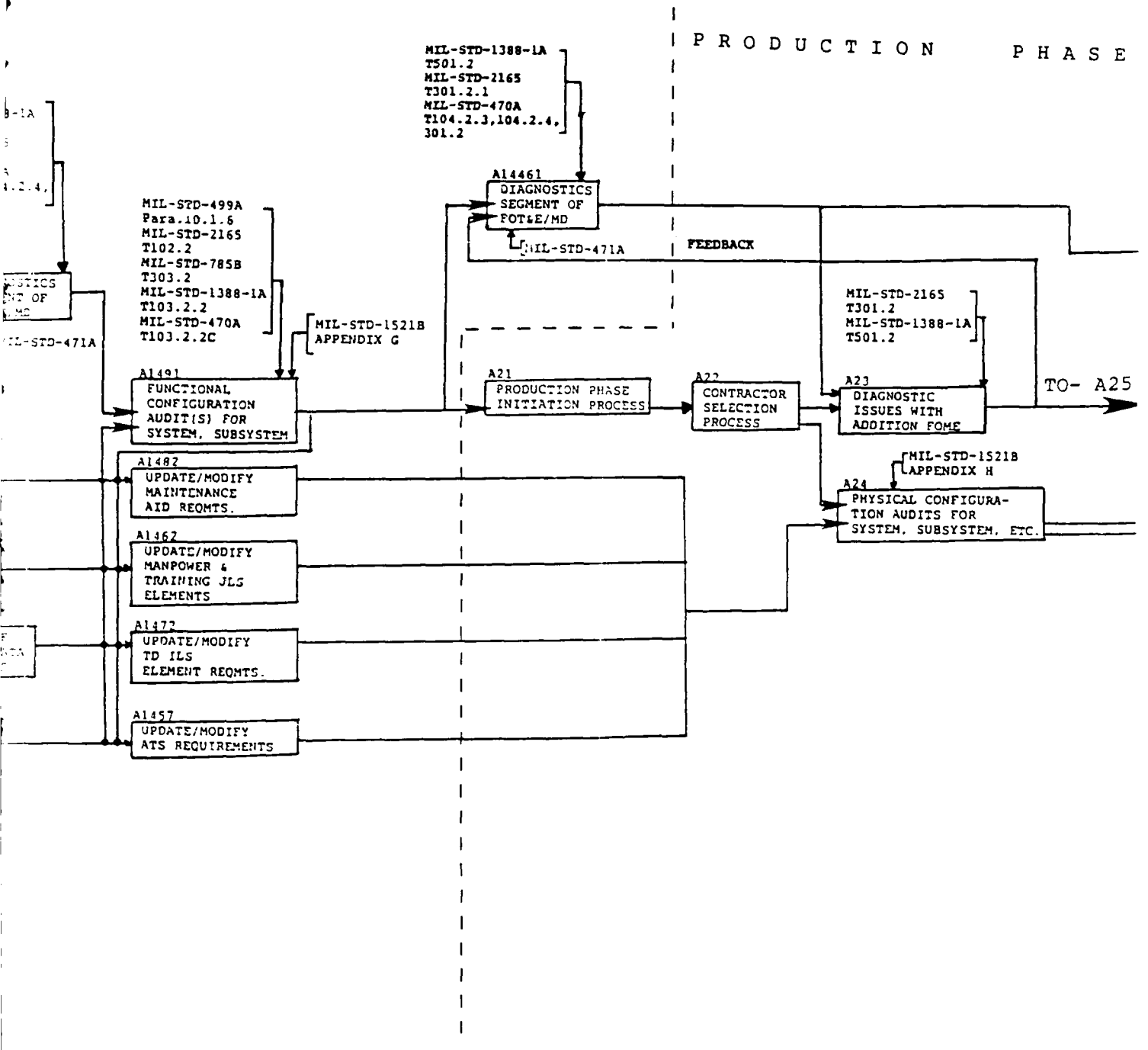
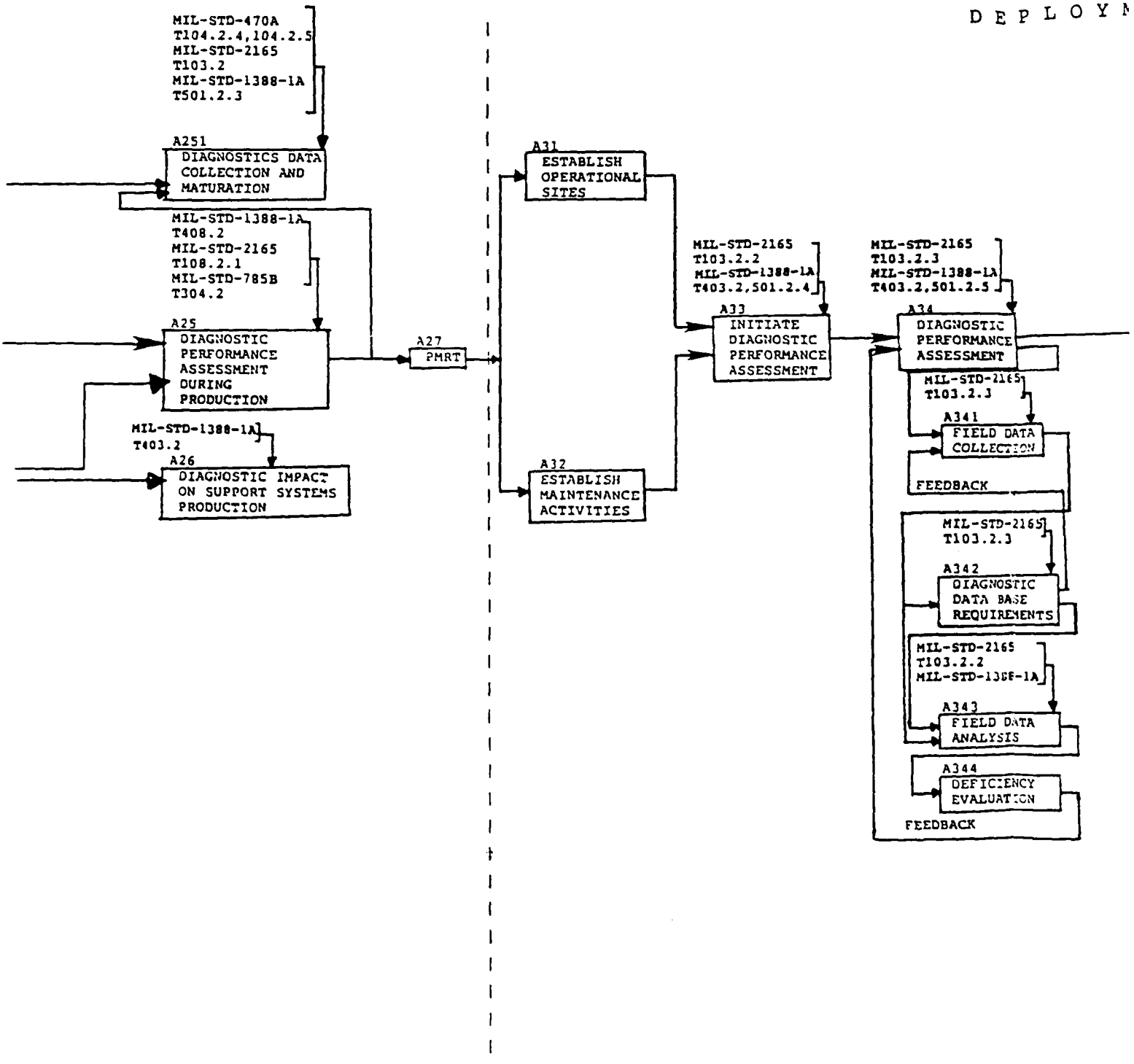


Figure B-7. Full-Scale Development And Production Phase Integrated Diagnostics Process


DEPLOY
MIL-STD-470A
T104.2.4,104.2.5
MIL-STD-2165
T103.2
MIL-STD-1388-1A
T501.2.3
A251
DIAGNOSTICS DATA COLLECTION AND MATURATION
MIL-STD-1388-1A
T408.2
MIL-STD-2165
T108.2.1
MIL-STD-785B
T304.2
A25
DIAGNOSTIC PERFORMANCE ASSESSMENT DURING PRODUCTION
MIL-STD-1388-1A
T403.2
A26
DIAGNOSTIC IMPACT ON SUPPORT SYSTEMS PRODUCTION
A27
PMRT
A31
ESTABLISH OPERATIONAL SITES
A32
ESTABLISH MAINTENANCE ACTIVITIES
MIL-STD-2165
T103.2.2
MIL-STD-1388-1A
T403.2,501.2.4
A33
INITIATE DIAGNOSTIC PERFORMANCE ASSESSMENT
MIL-STD-2165
T103.2.3
MIL-STD-1388-1A
T403.2,501.2.5
A34
DIAGNOSTIC PERFORMANCE ASSESSMENT
MIL-STD-2165
T103.2.3
A341
FIELD DATA COLLECTION
FEEDBACK
MIL-STD-2165
T103.2.3
A342
DIAGNOSTIC DATA BASE REQUIREMENTS
MIL-STD-2165
T103.2.2
MIL-STD-1388-1A
A343
FIELD DATA ANALYSIS
A344
DEFICIENCY EVALUATION
FEEDBACK

P L O Y M E N T P H A S E

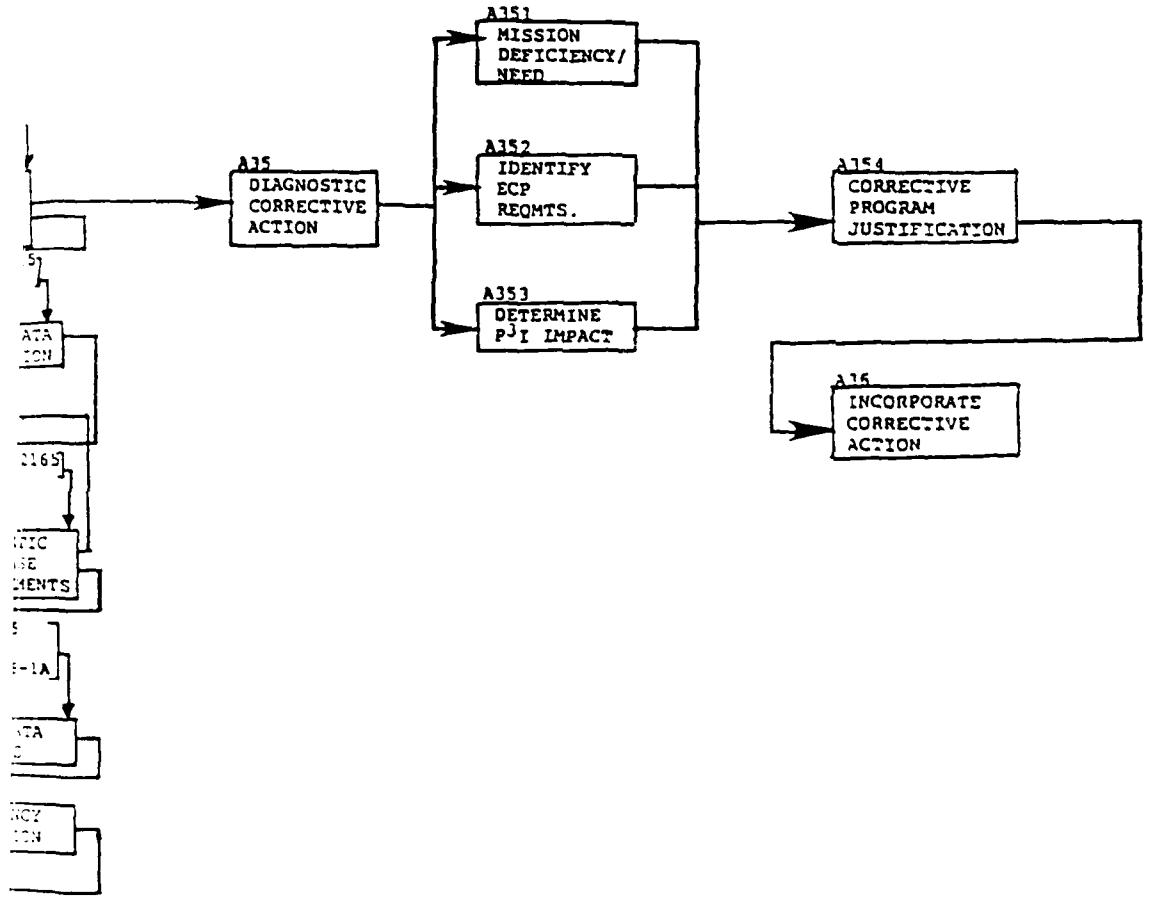


Figure B-8. Production Phase And Deployment Phase ID Process

APPENDIX C

NATIONAL SECURITY INDUSTRIAL ASSOCIATION'S INTEGRATED DIAGNOSTICS GROUP REVIEW OF THE IMPACT OF TESTABILITY/DIAGNOSTICS ON MILITARY STANDARDS

NOTE: This report, produced by the National Security Industrial Association, provided helpful recommendations which were thoroughly considered in the preparation of the Findings, Conclusions, and Recommendations contained in Section IV of this document.

NATIONAL SECURITY INDUSTRIAL ASSOCIATION

INTEGRATED DIAGNOSTICS GROUP

REVIEW OF THE IMPACT OF TESTABILITY/DIAGNOSTICS

ON

MILITARY STANDARDS

8 SEPTEMBER 1987

LOGISTICS MANAGEMENT
COMMITTEE

AUTOMATIC TESTING
COMMITTEE

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SECTION I

INTRODUCTION

The Rome Air Development Center (RADC), with support from the Office of the Secretary of Defense, is sponsoring a Testability/Diagnostics Encyclopedia Program. The first portion of this program is aimed at reviewing existing Military Standards in the fields of engineering, reliability, maintainability, logistics, technical information, software, and training with respect to essential testability/diagnostic coverage. The product from the first portion of this program will be proposed revisions to these Standards.

The analysis of these Standards has been completed. Before embarking on further definition of required revisions and identification of additional needs, RADC encouraged coordination with a wide variety of DoD and industry personnel engaged in the utilization of these Standards. An Interim Report was prepared and distributed which contained the results of this analysis.

At the request of the Rome Air Development Center, the National Security Industrial Association's (NSIA) Integrated Diagnostics Group reviewed this Interim Report and developed recommendations for improvement in the military Standards which control the acquisition of testability and the weapon system's diagnostic capability. The results of this analysis are contained in this report.

The NSIA Integrated Diagnostics Group met twice to conduct this review and analysis. The first meeting was in Pinehurst, North Carolina, on 15-16 July 1987. The second meeting was on 27 August 1987 in Anaheim, California. Appendix A is a list of participants at both the Pinehurst and Anaheim meetings.

A workshop environment was established at both meetings, with the specific purposes:

- To help focus attention of industry on needed Standards, which are essential to enable the implementation of testability and diagnostics into the design process.
- To examine current military Standards effort for effectness in the implementation of both testability and diagnostics.
- To identify and define specific Standards, modifications, and developments which are most needed and could be accomplished in the near future.

- To identify possible methods to accelerate development and implementation of these Standards.

Section II of this report contains a summary of the conclusions reached during these meetings. Section III contains the findings and recommendations for each of the military Standards which the group reviewed in relation to eight requirements which were established during the early phase of the RADC Program. Section IV is a summary of the report, with required actions identified.

SECTION II

CONCLUSIONS

Although the discussion and recommendations for each of the applicable military Standards are contained in Section III, discussion at these review meetings centered around a number of positive issues relating to these Standards. These discussions resulted in a number of conclusions which have wide implications in the content and use of these Standards. These conclusions can be summarized as follows.

- **Strengthen the development of a more effective and efficient diagnostic capability by promoting diagnostics/testability as in integral part of the system engineering process.**

With the advent of the term "Integrated Diagnostics," there is a tendency to invent a new "ility" to control the development of the diagnostic capability. However, Integrated Diagnostics is a process for the integration of all the diagnostic elements that contribute to diagnostics (e. g., fault-tolerant design, testability, testing, technical information, and personnel and training). Diagnostics is mission and performance oriented and should be measured as such. The concept of diagnostic growth should be employed in analyzing an demonstrating the performance of the diagnostic capability. Thus MIL-STD-499, which deals with the system engineering process, is a key Standard, which requires modification to implement Integrated Diagnostics and testability.

- **Integration of the "ilities" is required to provide a cohesive diagnostic design and evaluation process.**

The present diagnostic/testability design process is controlled by a number of programmatic and process Standards. These Standards deal with reliability, maintainability, human engineering, safety, testability, training, logistic support analysis, test requirements documents, test program sets, etc. There was a strong sentiment toward minimizing the number of Standards with duplicate or overlapping requirements that are applied to a weapon system program. These Standards require program plans, tradeoff analyses, and demonstrations, among other actions--all of which have a direct effect on the design of the diagnostic capability. In the far-term, combinations of these Standards should be promoted to provide a more cohesive diagnostic and support capability. In the short-term, methodologies should be developed, such as tailoring through the use of DIDs, to lessen the impact of fractionated "ilities."

- **Resist the temptation to develop additional Standards. Modification of present Standards to address diagnostics and testability appears feasible. Put requirement provisions in Standards and "how to" information in guides and handbooks.**

The group found no requirement for new Standards, except in the area of maintenance aiding and maintenance training for electronic delivery of this type of information. The group rejected the need for a Standard for embedded diagnostics design. The group identified a number of Standards which presently contain specific guidance or tools used in the diagnostic design process. Examples of this were MIL-STD-454J, which deals with design criteria for electronic systems, and MIL-STD-756, which provides detailed methodologies for predicting reliability. The trend should be to minimize placing this type information in Military Standards in order to allow contractors as much freedom as possible to do their job. In fact, the group rejected the need for a testability or a diagnostic analysis Standard, but recommended that such tools be incorporated in handbooks.

- **Military Standards should reflect new weapon system architecture, such as the development of Common Advanced Integrated Avionics.**

New weapon system architecture which incorporates dynamic reconfigurability, complex redundancy, and graceful degradation, requires a rethinking of the Standards used in the diagnostic design process. Questions arose on whether the present failure modes and effects criticality analyses were able to effectively address this new technology. Other new technologies, such as the electronic delivery of technical information; the employment of VHSIC circuitry; expert systems technology; and the integration of the diagnostic design process, with CAE/CAD/CALS; are all issues which will drive the requirements for Military Standards.

- **There is a need to strengthen the requirements portions of Standards and lessen the paper deliverables.**

As indicated above, there appears to be duplication among the paper deliverables invoked by a number of Standards and associated DIDs. A significant recommendation was made for MIL-STD-2165, which dealt with the strengthening of the requirements portion of this Standard to not only address testability, but the entire scope of diagnostics, and on the other hand, reduce the program monitoring, control, and demonstration requirements by placing the requirement for these functions in other existing Standards.

- **Maintainability demonstration techniques need to be updated.**

In concert with the abovementioned diagnostic growth concept, the maturation of the diagnostic capability must be planned, funded, and implemented. Demonstrations should be combined, where feasible. Data collected throughout the design and demonstration process should be collected and become the baseline for measuring the diagnostic growth of the system.

- **Diagnostic field performance data must be defined, collected, and analyzed.**

Each of the existing programmatic Standards requires that a data collection and analysis system be established for reporting, tracking, and measurement of the system's performance in relation to each of the "ilities." Again, the group did not recommend a separate diagnostic data base but, rather, the integration with other existing or planned data bases. The use of algorithms that are contained in RADC-developed handbooks to predict fault detection/fault isolation and false alarm levels identifies the data that is needed as inputs to the algorithms. When conducting prediction, empirical data is used as inputs. The collection of actual data and its use an inputs to the algorithms provides the actual fault detection and fault isolation levels. Field data collection presents a more difficult problem. The Standards should provide for requirements for the contractor to define field diagnostic performance data requirements and provide for the compatibility with the data collection system used during design with that utilized in the field.

SECTION III

FINDINGS/RECOMMENDATIONS

Requirement #1: Establishing Diagnostic Requirements and Allocating These Requirements for System, Subsystem, and Unit Levels.

MIL-STD-756 -- Reliability Modeling and Prediction.

Presently, MIL-STD-756B addresses both structured reliability analysis and mission reliability analysis. This Standard addresses conventional architectures, as opposed to newer architectures, which have complex redundancy, dynamic reconfigurability, and configurations allowing graceful degradation. It is recommended that this Standard not be revised at the present time to address these newer architectures, since the technology is not as stable. This type of prediction and modeling can be adapted to satisfy diagnostic needs and should be addressed in a Military Handbook or similar document, rather than in a Military Standard.

MIL-STD-1591 -- Analysis/Synthesis of On-Aircraft Fault Diagnosis, Subsystems.

This Standard establishes uniform criteria for conducting trade studies to determine the optimal design for on-aircraft fault diagnosis/isolation systems. There is a need to expand this methodology to address all types of equipment and all types of diagnostic elements within these equipments and systems. However, it is recommended that the requirement for such analyses be included in the revised MIL-STD-2165 and that the tools and techniques be included in a Military Handbook or guide.

Requirement #2: Describing Various Testability/Diagnostic Tasks Which Must be Undertaken During Each Phase of Weapon System Acquisition.

MIL-STD-2165 -- Testability Program for Electronic Systems and Equipments.

MIL-STD-2165 was initially prepared to influence the design and integration of testability into the acquisition process for electronic systems and equipments. As such, it is very close to being a standard which implements the concept of Integrated Diagnostics. A very significant modification was proposed by the group. The intent of this proposal was to strengthen the design and integration portion of this Standard, while lessening the requirements for program monitoring and control and test and evaluation by utilizing other existing Standards to perform these functions. Specific recommendations follow.

Task 101 -- Testability Program Planning.

Task 101 calls for the development of a Testability Program Plan or a testability plan which is integrated into the SEMP or other management plans. Integrated Diagnostics is part of the system engineering process and thus should be stressed in the System Engineering Management Plan (SEMP). The SEMP requirement is usually contained in the weapon system Statement of Work, under the Systems Engineering Process, as defined by MIL-STD-499. The diagnostic requirements can be addressed by the other "ility" plans. The ultimate recommendation is to place Integrated Diagnostics into the SEMP, along with the other "ility" plans. This would require a major modification to a number of Standards, as well as to their associated DIDs. The near-term approach would be to emphasize integration of diagnostics in SEMP, while tailoring the diagnostic inputs to other "ility" program plans through the use of DIDs.

Task 102 -- Testability Reviews.

The recommendation is to put adequate testability/diagnostic review criteria in MIL-STD-1521, Technical Reviews and Audits for Systems, Equipment, and Computer Programs.

Task 103 -- Testability Data Collection and Analysis Planning.

Each of the programmatic Standards addresses the need for data collection and analysis. MIL-STD-2165 addresses the need for planning for this function. Therefore, other programmatic Standards, such as MIL-STDs 785 and 470, can be tailored to address this requirement by integrating the data needs with those already required for reliability and maintainability.

Task 301 -- Testability Inputs to Maintainability Demonstration.

This task already puts the burden of demonstrating testability and diagnostics on MIL-STD-471.

Task 200 Series --

This series addresses Testability Requirements, Testability Preliminary Design and Analysis, and Testability Detailed Design Analysis. While this Standard addresses testability in a broad sense, it must be expanded to fully address all diagnostic elements which constitute the diagnostic capability (i. e., testing, technical information, and personnel and training). In addition, a number of other diagnostic and Integrated Diagnostic concepts must be addressed. Among these are: additional emphasis on translating mission requirements into FD/FI requirements; tradeoff analyses; the diagnostic growth concept; diagnostic

allocations; and maturation methodologies. A new 200 Series of tasks should be developed, dealing with such subjects as allocation, testability, performance monitoring, reconfigurability, BIT, and nonembedded diagnostics, and the title of the document should be changed to reflect all diagnostic elements.

In addition, the scope of this Standard should not be limited to electronics, but should address the entire weapon system's diagnostic capability.

MIL-STD-470A -- Maintainability Program Requirements.

The relationship between this Standard and other programmatic Standards is not clear (e. g., MIL-STD-1388-1A and MIL-STD-2165). This needs to be clarified.

MIL-STD-499A -- Engineering Management.

This Standard provides the basis for Integrated Diagnostics. However, diagnostics is neither identified nor addressed. The Standard should be modified to assure that Integrated Diagnostics is made an integral part of the system engineering process.

MIL-STD-1629A -- Procedures for Performing a Failure Mode, Effects, and Criticality Analysis.

The outputs from this Standard are applied to a number of other applications and Standards (e. g., testing, safety, maintainability). In addition, modern dynamic reconfigurable systems require a re-look at FMECA techniques. This Standard must be analyzed completely to see how it can be better utilized in providing a cohesive diagnostic design process.

DOD-STD-2167 -- Defense Systems Software Development.

This Standard deals with both operational and diagnostic software. It is recommended that only diagnostic software and its interface with operational software be addressed by the diagnostic community.

MIL-STD-1379C -- Contract Training Program.

This Standard emphasizes normal methods of training, such as the utilization of technical manuals for instructional material. Although one section deals with on-the-job training handbooks, the Standard does not address on-the-job training in relation to electronic delivery devices. This new methodology must permeate throughout this Standard. In addition, the electronic delivery device can not only deliver on-the-job training information, but also can deliver technical information which is normally contained in a technical order or manual. The interface between

these two types of information must be described and methods for generating this information must be made compatible.

Requirement #3: Designing the Diagnostic Capability.

MIL-STD-454J -- Standard General Requirements for Electronic Equipment.

This Standard contains general requirements for electronic equipment, which are oriented toward hardware. Reliability, maintainability, and human engineering are included, with the proviso that they must not be referenced in contractual documents. It is recommended that Integrated Diagnostics not be added to this Standard and, if any of the diagnostic elements are included, they should be hardware related. The consensus was that MIL-STD-454 is a "handshake" type document that only benefits the Specification preparer and not the user. In addition, it is recommended that Requirement # 32 in this Standard, Test Provisions, should not address off-line test (e. g., ATE, manual test equipment). It is felt that this material should be part of MIL-STD-415.

MIL-STD-415D -- Design Criteria for Test Provisions for Electronic Systems and Associated Equipment.

This Standard depicts design criteria for test provisions for electronic systems and associated equipment. It is outdated. The recommendation in the Rome Air Development Center report suggests that the Standard should be updated to address new technologies, such as performance monitoring, VLSI/VHSIC, fault tolerance, prognostics, and sensor requirements. It is recommended that the list of these newer technologies be expanded to include fault logging and reporting methods, communication standards, test of nonelectronic equipments, time-stress measurement devices, etc. It is also recommended that the document be broadened to include hardware-specific diagnostics: for example, test buses. It is recommended that the revision to this Standard be a total rewrite and not merely a "band-aid" revision.

MIL-STD-2084 (AS) -- General Requirements for Maintainability of Avionic and Electronic Systems and Equipment.

This Standard has been canceled for use on new applications. The RADC report recommended extracting the valid portions of this Standard and putting them in various documents, including a new on-line diagnostic Standard. It is recommended that a new on-line diagnostic Standard not be prepared. Specific, valid diagnostic provisions should be placed in existing Standards (e. g., MIL-STD-415), with title changes for DoD-wide application.

MIL-STD-1472C -- Human Engineering Design Criteria for Military Systems, Equipment, and Facilities.

The finding/recommendation contained in the RADC report is supported. It is recommended that the Standard be analyzed to ascertain if test point access is adequately covered.

MIL-STD-2076 (AS) -- General Requirements For a Unit Under Test Compatibility With Automatic Test Equipment.

Agree with recommendation in the RADC report.

MIL-STD-1326 (Navy) -- Test Point, Test Point Selection, and Interface Requirements for Equipments Monitored by Shipboard On-Line Automatic Test Equipment.

It is recommended that certain portions of the Standard, such as the disclosure format, be removed from this Standard and placed in a guidance document. Examples of its use with non-electronic systems should be developed, using this disclosure format.

MIL-STD-1345B (Navy)/MIL-STD-1519 (USAF) --
MIL-STD-1519 (Update for MATE) -- Preparation of Test Requirements Documents.

The finding/recommendation and proposed activity in the RADC report is valid, with a proviso that the inclusion of automatic test program generation and computer-aided engineering and design requirements in MIL-STD-1519 be generic, to allow use by many different test program generation systems.

MIL-STD-2077 (AS) -- General Requirements for Test Program Sets.

Appendix A, which addresses test program instruction formats, should include means for electronic delivery of this data.

MIL-STD-1685 (SH) -- Comprehensibility Standards for Technical Manuals (Metric).

It is recommended that this Standard address requirements for electronic delivery of technical information.

Requirement #4: Conducting Design Reviews.

MIL-STD-1521B (USAF) -- Technical Reviews and Audits for Systems, Equipment, and Computer Programs.

Agreement was reached on the finding/recommendation contained in the RADC report, which proposed a significant expansion for diagnostic-related activities when conducting design reviews.

Requirement #5: Analyzing and Assessing the Performance of the Diagnostics Capability During Prime System/ Weapon System Design.

MIL-STD-2080A (AS) -- Maintenance Engineering, Planning and Analysis for Aeronautical Systems, Systems, Equipment, and Support Equipment.

Agreement was reached that this Standard not be utilized by the Air Force and that it essentially duplicates the purpose of MIL-STD-1388-1A.

Requirement #6: Assuring Delivery of Adequate Diagnostic Capability.

MIL-STD-471 -- Maintainability Verification/Demonstration/ Evaluation.

The following is recommended:

(1) A family of curves for various confidence levels is required.

(2) The procedures in Appendix B identify a symbol that represents sample size. However, nowhere in the procedures is the sample size defined. This must be done in order to use the procedure.

(3) Definition of a sequential test or the insertion of multiple faults must be included.

(4) One hundred percent diagnostics prediction/evaluation can be accomplished using the procedures contained in MIL-STD-471. It is just a matter of time and money in terms of the iterative running of the procedures.

MIL-STD-781C -- Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution.

The Standard should be expanded to include Bayesian reliability demonstration techniques being planned under Reliability Standardization Project 0026.

Requirement #7: Collecting/Analyzing Data on the Performance of the Diagnostic Capability.

MIL-STD-1388-2A -- Logistic Support Analysis: Data Element Definitions.

Two very similar routes of documenting failure mode data are currently implemented in both MIL-STD-1629 and MIL-STD-1388-1A. MIL-STD-1629 uses a "worksheet" to document failure modes and MIL-STD-1388-2A uses data sheets B1 and B2 to document FMECA. Neither method provides additional information that clearly separates one analysis from the other. As a matter of fact, 1388-2A states that under no circumstance shall a contractor be required to perform both analyses. Only one effort should be performed.

Unfortunately, this leaves a gap that needs to be bridged. A means of relating failure mode data to detection methods in the support of technical manual/technical order generation needs to be emphasized in the LSA process. The current push in the LSA community is the identification of failure modes that result in a direct relation to a specific task (i. e., repair action, inspection, etc.). Many failure modes, however, may result in the same task and, therefore, require a lot of redundant effort. Consequently, the emphasis in the LSA process should be placed on the way a failure is detected, not the failure itself. A maintainer/operator could care less that a particular signal is stuck high. He wants to know the indication that flags him to start a fault isolation procedure. The result would be an analysis on how to fault isolate, not remove/replace. This information could then be more suited to the generation of fault reporting/isolation manuals.

Requirement #8: Standardization of Definition.

MIL-STD-721C -- Definition of Terms for R&M.

MIL-STD-1309C -- Definition of Terms for TMDE.

It is recommended that:

(1) Diagnostic terms should be defined in a single Standard.

(2) Combine MIL-STD-1309 and MIL-STD-721C and make the title broader than Reliability and Maintainability.

SECTION IV

SUMMARY

This report completes the review of Military Standards by the NSIA Integrated Diagnostics Group. It is recognized that the group, meeting in a one- or two-day workshop environment, could not provide detailed analyses of all of the applicable Standards. However, this review provided a positive sounding board which can be used in the revision of these Standards.

APPENDIX

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LIST OF PARTICIPANTS

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11.	Don Seidenspinner	Grumman
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21.	Jerry Klion	RADC
22.	Frank Born	RADC
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